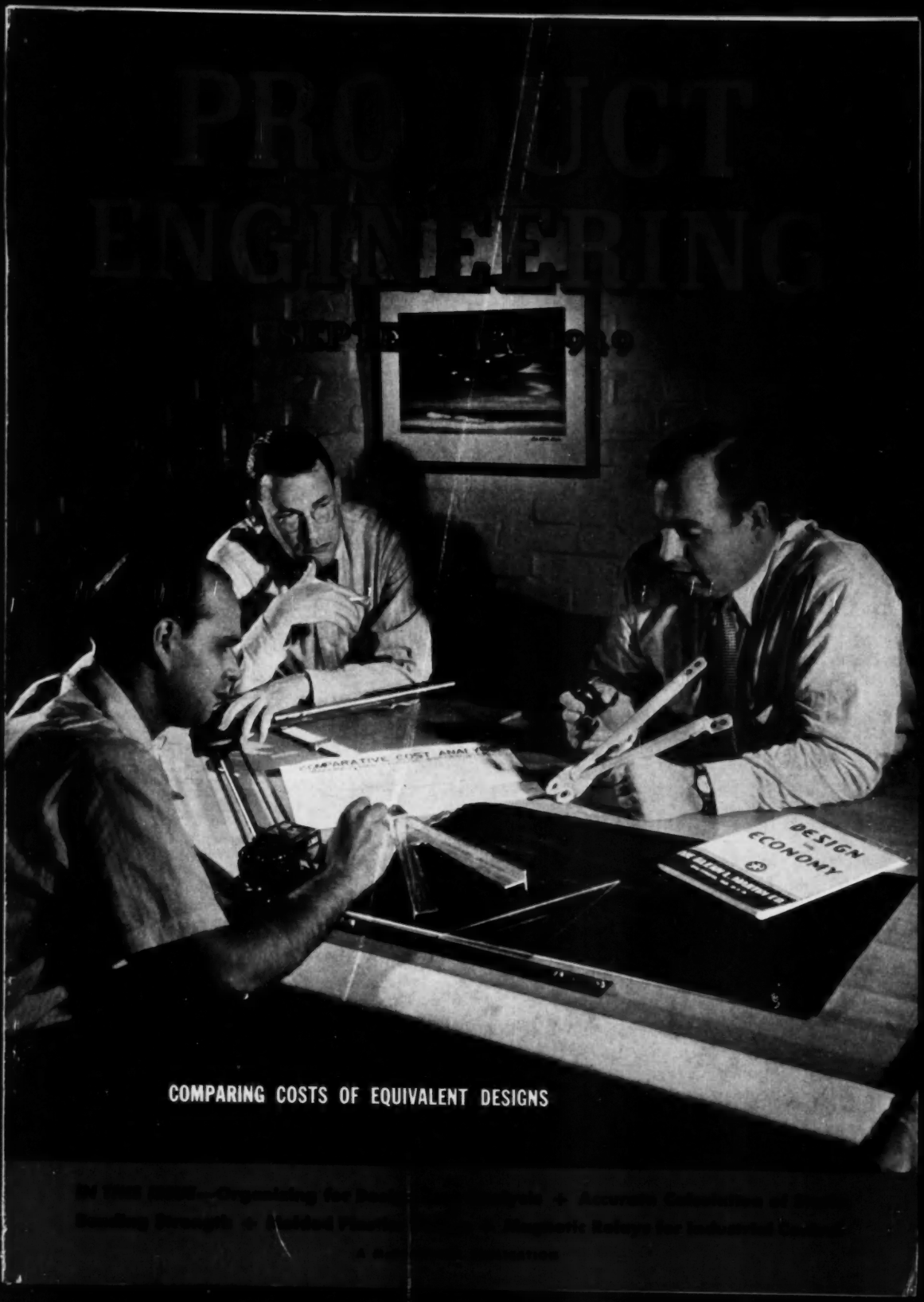

COMPARING COSTS OF EQUIVALENT DESIGNS

WHAT'S THE

Important Difference

BETWEEN

Carbon Steels and Alloy Steels?

No SINGLE characteristic denotes the real difference between alloy steels and carbon steels.

Certain of the most useful mechanical properties—strength, hardness, toughness, ductility—can be developed to a high degree, individually *but not collectively* in carbon steels.

Nor can such desirable characteristics as response to mild quenching, high strength and elastic properties in large sections, and good resistance to distortion and cracking in heat treatment of complex shapes be developed in carbon steels.

In nickel alloy steels *all* of these characteristics can be obtained, in greater or lesser degree, *at the same time*. From among the many grades of standard alloy steels containing nickel it is possible to select one which provides the best set of properties for meeting virtually any reasonable requirements.

Yes, in the final analysis, it is the better, more complete *combination* of properties—and, therefore, better performance and long-range economy—available in the nickel alloy steels which constitutes the most significant difference.

We shall be glad to furnish counsel and data to help you select the right nickel alloy steel for your requirements.

INCO

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

VOLUME 20 **PRODUCT ENGINEERING** NUMBER 9

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FP FOR TV

Television Demands Extra Margins of Safety

Everyone knows that higher temperatures hasten the destructive forces of corrosion. It's equally obvious that a capacitor which will take this extra punishment will stay on the job even longer at lower temperatures.

When you specify Mallory FP Capacitors for television receivers, or any equipment where heat is a problem, you can be sure they will stand the gaff . . . they've always been designed to operate successfully at 85° C. And at normal temperatures, you get an extra margin of safety that pays off in longer, trouble-free performance.

Best of all, *you pay no premium* for this added dependability. Write for your copy of the new FP Capacitor Engineering Data Folder.

FP is the type designation of the Mallory developed electrolytic capacitor having the characteristic design pictured and famous throughout the industry for dependable performance.

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Power Supplies
Resistance Welding Materials

Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

METALLIC MATERIALS

A LESS EXPENSIVE ALTERNATE for chromium plating is an alloy made up of 80 percent tin and 20 percent zinc. Coating's corrosion inhibiting and solderability characteristics make it particularly useful on steel in a variety of electrical applications.

RESEARCH AND DEVELOPMENT ON TITANIUM has progressed at an ever-quickening pace since the war. Special alloys of the metal appear to be the answer for supersonic structures--their physical properties remain stable at elevated temperatures, their strengths outdo those of aluminum and weights undercut those of steel. Look for the complete story of progress to date in the November PRODUCT ENGINEERING.

SPECIAL GRADE OF STAINLESS STEEL combines several properties useful in fabricating gears, cams, shafting, chains, valves and pump parts. 16.5 percent Cr, 4.25 percent Ni, 4 percent Cu provide corrosion resistance approaching that of 18-8, a hardness of Rockwell C40 to 45 and an annealed strength of 135,000 psi. Hardening at only 900 F increases the ultimate to 195,000 pounds per square inch.

"NEW WRINKLE" IN ALUMINUM for aircraft construction is a variation of the well-known honeycomb sandwich. Half-inch

strips of aluminum foil 0.001-in. thick are corrugated, crinkled and then nested on edge to form the core of a Fiberglas sandwich. Product is claimed to be ten times stronger than similar materials and 30 percent lighter in weight. Cost is 35 percent less than that for glass honeycomb construction.

A STAINLESS STEEL conveyor belt was recently put through vigorous tests in a West Virginia coal mine. This use of the material proved highly successful. Stainless belts would not replace existing types but would probably be used in combination with rubber belts, especially when steep slopes are encountered.

NEW ALLOY CAST STEEL containing 19.5 percent Cr and 9 percent Ni has significant physical properties at temperatures down to -400 F. Tensile strength varies inversely with temperature--its 200,000 psi at -423 F--and directly with hardness. Uses are anticipated in the oil, chemical and process industries.

NONMETALLIC MATERIALS

A VINYL PLASTIC COAT less than 0.002 in. thick may become a competitor for common

galvanized finishes used on steel tubing. Applied in two coats, film can be bent, expanded, flanged, fluted or flattened without rupture. In salt spray tests, plastic outlasted galvanized samples by nearly 2,000 hours.

NEW SILICONE RUBBER is described as toughest, most stable composition of this class; outperforms other rubber-like products when it comes to tensile strength, tear resistance, elongation and electrical properties in the range from -130 to +500 F. Low specific gravity of 1.1 to 1.3 results in reduced costs for 25 to 75 percent more parts per pound of stock.

NYLON'S YOUNGER BROTHER, Saran, is proving effective as a protective coating in marine installations. Fuel oil tanks and ship hulls coated with the material show no signs of corrosion.

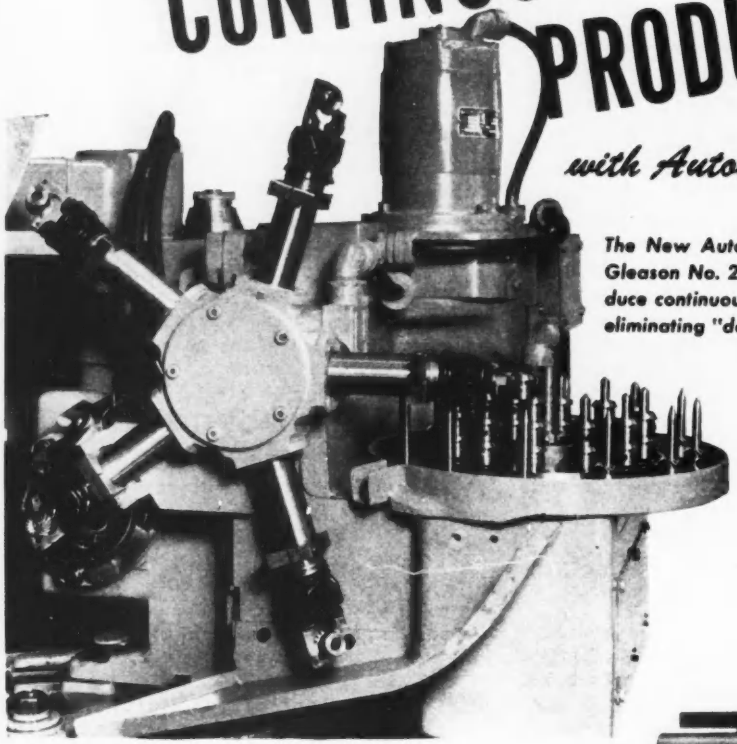
BOUNCING PUTTY has finally been put to practical use--as a shock absorber for

sensitive instruments in V-2 rockets. A half-inch "coat" of the material inside the armored housings of heliograph cameras and recorders cushions the shock when the rocket lands.

Continued on Page 5

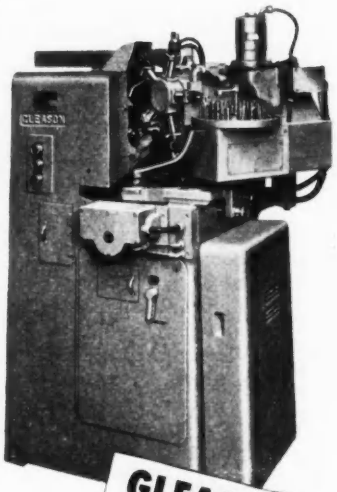
CONTINUOUS PRODUCTION

with Automatic Loading



The New Automatic loader enables the Gleason No. 2 Hypoid generator to produce continuously without stopping—thus eliminating "down time" on the machine.

The Gleason No. 2 Hypoid Generator is a versatile generator, providing close control of actual cutting at faster times than previously possible. This machine produces spiral bevel, Zerol bevel and hypoid gears and curvic clutches in the small sizes (16 D.P. and finer) with a superior tooth bearing. Whether it is used for jobbing or production, the No. 2 Hypoid Generator is ideally suited for the production of bevel and hypoid gears for small tools and appliances.



GLEASON
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Builders of Bevel Gear Machinery for Over Eighty Years

MELTED POLYETHYLENE fed through a slit becomes a tape in which telegraphic messages are punched. After message is transcribed, tape is returned to heated reservoir and melted again for reuse.

CELLULOSE ACETATE SHEETS 60 in. wide--6 in. more than previously-- will expand the uses for Vuepack and Fibestos as packaging and protective covering materials. Greater economies and wider latitude for patterns are the chief benefits.

MEDIUM-HIGH-IMPACT PHENOLICS, called Luron, have low bulk, are fast curving and emerge from mold with a high gloss finish. They're adaptable to compression, transfer or plunger molding, and applicable for transformer housings, electrical outlet boxes, industrial light sockets and coil forms.

PROCESSES

A COLUMN OF OIL may replace metal punches used for piercing and blanking silicon steel sheet. Oil can be channeled back and reused while worn out metal punches become useless. Soft, unhardened steel dies will therefore become practical.

KARAT GOLD as thin as electroplate can be rolled to a mirror finish on any nonferrous metal base. This Inter-Weld process welds instead of silver solders the gold to a barrier layer of pure nickel. The dual layer is then soldered to the base metal by conventional methods. The rolled gold is tougher than electroplate.

CATHODIC VACUUM ETCHING is a new trick for preparing metal surfaces for microscopic study and photography. Metal sample is placed in a partial vacuum with argon. With the application of a 12,000-v charge, argon ions bombard the surface and bring out in relief the true microstructure.

STEEL-SHEATHED tubular heating elements cast as inserts in aluminum die castings form a grid for a room heater. Cost savings over sand-casting methods are 44 percent for a small circular grid and 52 percent for a larger rectangular unit. Interesting feature of larger assembly is an aluminum bar insert that supports the element during casting.

STABLE GRAPHITE FILMS can be easily applied to metals, plastics, rubber, ceramic and plated surfaces. Films vary in thickness from 0.00015 to 0.0005 in. Highly desirable lubrication characteristics are obtained in the temperature range from -120 to +200 Fahrenheit.

ALUMINUM ALLOY FRAMES for automobile doors are now being cast in a 13-ton die. The castings weigh 13½ lb and measure 43 3/8 by 33 in. Machining and subassembly operations and related costs are thereby cut, weight reduced. Thirty doors an hour can be produced.

PRODUCTS

INJECTION MOLDING MACHINE combines an extruder with a vertical transfer press. Extruder plasticizes compounds and feeds measured shots directly into a torpedoless injection cylinder. Net result--injection pressures for a 23-oz shot of polystyrene of only 3,100 psi. Built in 48-60 and 80-oz sizes, machine is fast-cycling and automatically timed.

A "HOSELESS" REFUELING SYSTEM makes mid-air transfers a relatively simple operation. A cylindrical boom flexibly mounted on the tail of the tanker plane fits a nose coupling on a bomber. Small control surfaces on the end of the boom enable the tanker crew to "fly" the boom into position for contact. High pressure pumps then take over.

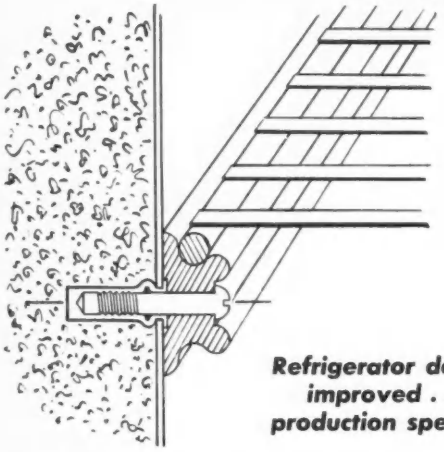
FULLY AUTOMATIC die-casting machine of German design turns out 2- and 3-lb magnesium alloy castings. It's of the hot chamber, injection type.

WIDE-RANGE ELECTRIC POWER CONTROLLER installed at the Bureau of Standards does not allow power to vary more than 0.005 percent. Continuously variable voltage from 500 to 50,000 at maximum of one milliampere is produced from a radio frequency oscillator, power amplifier, RF transformer and a ladder-type voltage tripler circuit. The 40 kc source and filters reduce output ripple and permit extremely accurate test measurements.

CHEMICAL PROTECTION of electric motors is reported to be cheaper by greater use of

Continued on Page 7

RIVNUTS solve tough fastening problem

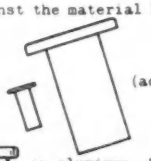


Refrigerator design improved . . . production speeded

FASTENING an extruded plastic strip to the porcelainized inner wall of a refrigerator posed some tough problems for design engineers. The bucking action of conventional riveting cracked the porcelain finish. And the air-tight seal was difficult to maintain.

Both problems were quickly licked with a blind-end B. F. Goodrich Rivnut. The Rivnut was smoothly and easily upset with the heading tool. No bucking needed. No damage to the finish. The tight fit of the Rivnut combined with its closed end to provide perfect insulation. And the clean, still-intact Rivnut threads furnished an excellent nut plate for screw attachment of the plastic strip.

Rivnuts saved many man-hours. And they improved the design by providing easy maintenance of the shelf-holding strips without removing the wall. The answer to *your* tough fastening problems may lie in Rivnuts. Why not call in a Rivnut engineer? Write the B. F. Goodrich Company, Dept. PE-99, Akron, Ohio.

HOW RIVNUT WORKS: Rivnuts are upset with a heading tool (hand or hydraulic) that transmits a pull on the threaded portion so that the counterbore (which is thinner) has to give. A bulge starts to form and the threads push the counterbored portion until the expanding metal seats itself firmly against the material being fastened Rivnuts are available in a wide range of sizes  (actual size) with countersunk, brazier, or flat head in aluminum, brass and steel.

B.F.Goodrich

RIVNUTS

The only one-piece blind rivet with threads

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO *and* fasten WITH. Explains construction, gives applications. Write to The B. F. Goodrich Company, Dept. PE-99, Akron, Ohio.

corrosion-resistant metallic parts and plastic insulation rather than more elaborate mechanical enclosures. This trend applies to a-c units up to 15 hp and d-c assemblies up to 60 horsepower.

RECTANGULAR SHAPED BELT CONVEYORS have rubber zippers that handle breakable materials with kid gloves. Non-contaminating and adaptable where space is limited, system is particularly suited for handling bulk foods, chemicals and granular products. Rubber teeth lock materials within the belt after they are deposited in the trough formed by the belt. Vertical runs of the system do not require casing or framing.

TESTING

A VIEWFINDER for aerial photography presents an erect, unreversed image. Device consists of two integrated optical systems--one, a wide-angle system for scanning a large area of terrain; the other, a drift-meter system for covering the ground directly below. The Navy sees three uses--controlling photographic flight paths, observing rescues under helicopters and aligning planes when landing on carriers.

CABLE TESTING MACHINE tests multi-strand specimens 55 ft. long. Special extensometer and recorder equipment provides accurate stress-strain curves at point along the specimen; other accessories indicate conditions where samples are stretched to failure. Four load ranges vary from 1,200 to 120,000 pounds.

PHOTOELECTRIC SPECTROPHOTOMETER records more than two million shades of color as curves on a graph. Instrument saves about 70 percent of time needed to match porcelain enamel colors by existing methods.

TIRES can now be built without cross treads to space the cords--result, the cords are free to flex thereby distributing the load more efficiently among the working cords. The treads won't be missed at all--they carry no load, and serve merely as an assembly expedient.

SIZABLE COST REDUCTIONS can be realized by analyzing and redesigning testing procedures and equipment. One company has applied this thesis to reduce the time for testing hydraulic pumps by more than 50 percent. A full range of pumps fits the test bed and units can be interchanged easily and quickly. Readings are recorded on a set of remotely controlled instruments.

ELECTRICAL & MECHANICAL PARTS

AUTOMATIC SAFETY STARTER for fluorescent lamps contains a thermal relay that protects the transformer, fixture and starter itself from overheating. If lamp does not light within 30 sec, relay automatically opens the circuit.

ILLUMINATED SIGN has interchangeable letters--they're green when lit, white when turned off. Figures light up immediately when installed in a groove against a glossy black background. High frequency induction does the trick. Can be used on regular a-c line or on d-c with a converter.

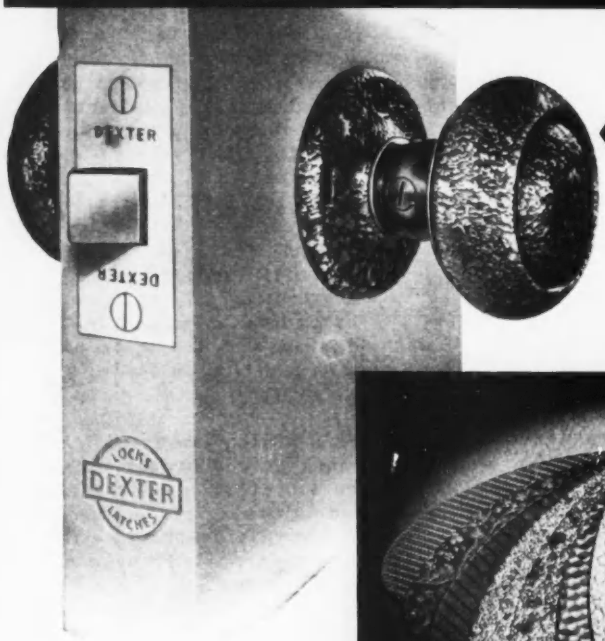
END-THRUST BEARING that works with plain radial bearings on rod or bar mills is adaptable for installation where one end of the roller is open. Device does away with wearing-type, side-thrust collars and allows precise control over axial matching of roll passes.

AN ALPHA RAY COUNTER is more sensitive than the Geiger tube when it comes to measuring very slight amounts of radioactivity. Photo-multiplier tubes count alpha particle scintillations and give statistically accurate figures during comparatively short test runs. Device is about the size of a table-model radio.

A TRACK-TREAD LANDING GEAR is being tried on a B-50 bomber. The two units consist of endless steel-wire and rubber belts that rotate around a series of grooved drums. Treads have a "footprint" three times the area of double tires, yet there is no sacrifice in speed.

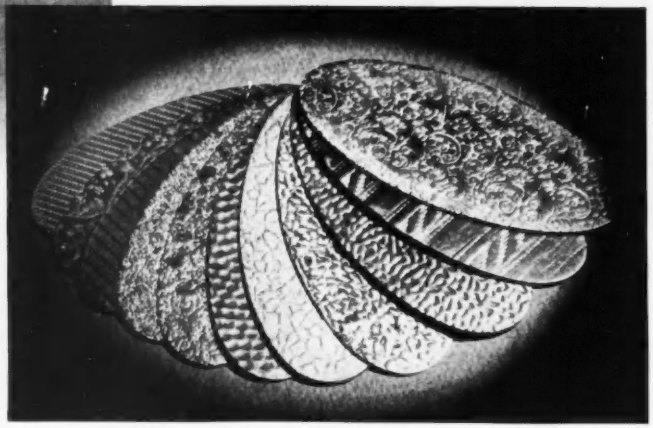
WORM GEAR has ball bearings between worm and gear to reduce friction. Semi-circular recesses in the gear match a spiral groove in the worm. Opposite ends of the spiral groove are connected by a passageway in the center of the shaft. Balls in this passage transmit the torque.

REVERE EMBOSSED METAL ADDS TO BEAUTY of Solid Brass Hardware



A Dexter set made by National Brass Company, Grand Rapids, Michigan; in the lifetime beauty of solid brass. Knob is fabricated from a Revere Embossed Pattern.

Inset, some embossed patterns produced by Revere.



Quality hardware for homes and commercial buildings always is solid brass or bronze. There are no substitutes for these solid, ever-lasting metals that cannot rust, whose beauty is not skin deep but goes all the way through. Thus time and use improve the finish instead of spoiling it. That is why good buildings everywhere feature solid brass and bronze for such items as locksets, door knobs, butts, latches, hangers, hooks, and similar parts that should speak of quality as long as the building stands.

Take the National Brass Company. This well-known hardware manufacturer features solid brass 100%, knowing that any architect, builder or home owner recognizes the worth of enduring high quality. Their line is trademarked "Dexter", and one of its feature items is trim in etched finish. Actually these items use solid Revere Embossed Brass, which is furnished in a variety of standard and special patterns, ready for fabrication into articles of exceptional attractiveness, not only hardware, but also a wide range of products such as compacts, clock dials, cigarette cases, jewelry. National Brass states that Revere Embossed Brass not only produces a really handsome line, but one whose beauty increases with age, since use brightens the high-lighted raised surfaces, while the shadows in the depressions provide an effective contrast. Thus this fine Revere Metal assures lasting satisfaction to the home owner, and enhances the reputation of the architect, contractor, and builder. . . . For true quality, high sales appeal, and enduring service, wise manufacturers use solid durable metals such as copper, brass, bronze, nickel silver provided by Revere not only in Embossed Metal but in plain sheet and strip and in bar, rod, extruded shapes.

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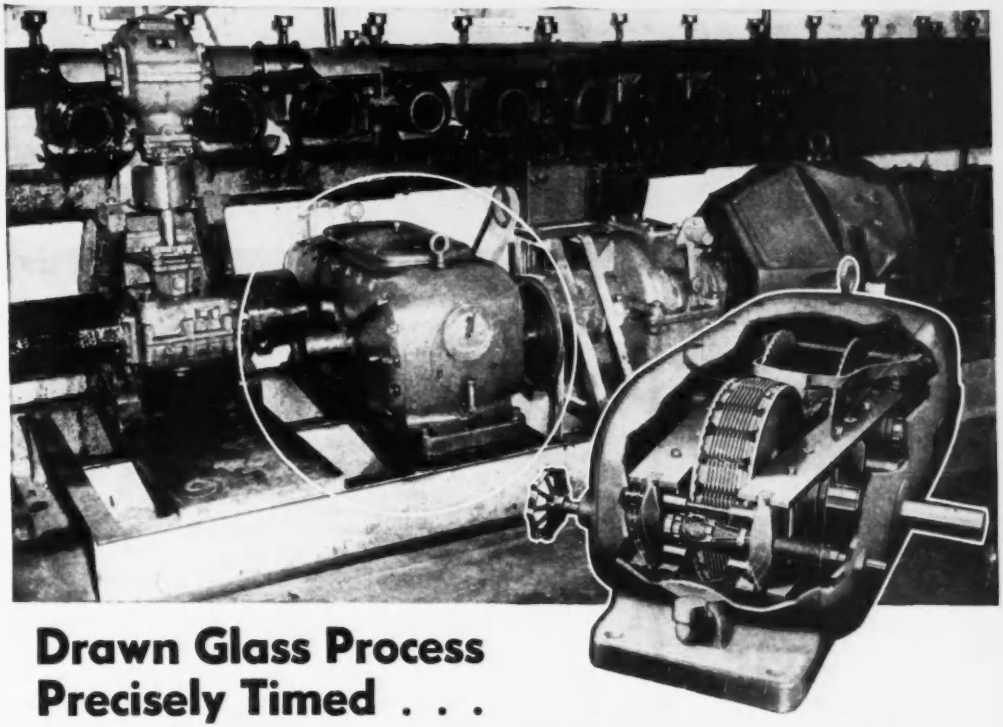

Drawn Glass Process Precisely Timed . . .

by Link-Belt P.I.V. Variable Speed Drive

Lehr Rolls Accurately Synchronized with Drawing Machine to Avoid Buckling

In making drawn sheet glass, the drawing machine and annealing lehr must be kept "in step" to avoid deformation of the still plastic sheet. In the Libbey-Owens-Ford window glass factory at Shreveport, La., this is accomplished by means of Link-Belt P.I.V. Variable Speed Drives. In one instance, the drawing machine is driven through a P.I.V. Variable Speed Drive, allowing its speed to be accurately calibrated to that of the lehr. In the application illustrated, the P.I.V. Variable Speed Drive is used in driving the lehr rolls, whose speed is calibrated to agree with that of the drawing machine.

LINK-BELT COMPANY

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Houston 3, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices in Principal Cities.

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LINK-BELT

Power Transmission Machinery
"THE COMPLETE LINE"

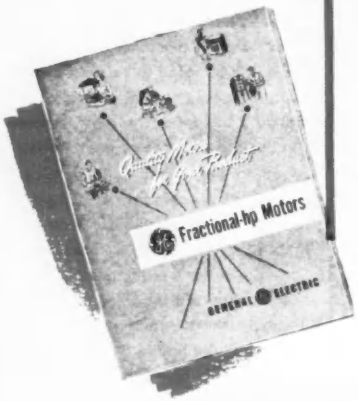
Machinery builders incorporate Link-Belt P.I.V. Variable Speed Drives in the mechanisms of many types of glass working machinery, and they are easily adapted to existing drives using speed change gears. The unique principle of the P.I.V. Variable Speed Drive allows the machine speed to be varied while running, rather than requiring a stop for gear change. It also provides for an infinite range of speeds, without stop. Speed once set is maintained indefinitely without slip or creep. Simple, durable and efficient, the Link-Belt P.I.V. Variable Speed Drive requires practically no attention or upkeep. Available in plain or motorized models, with or without extra reduction gears, for vertical or horizontal mounting, up to 25 H.P.

• • •

Send for Book 1874-B, giving full description and application data.

Designer's

What do you need in a fractional-hp motor?



. . . operation on polyphase power? Here it is — the General Electric Type K induction motor for any standard application with polyphase power supply. Use it for pumps, compressors, fans and blowers — wherever the motor must deliver constant speed for long periods. Also available are totally-enclosed motors for machine tools.

. . . operation on d-c power? When the power supply is d-c, use the General Electric Type BC direct-current motor for either constant or adjustable speed. Like all G-E motors, it's quality-built to help sell your product.

. . . constant speed and moderate torque, single phase? Specify this General Electric Type KH split-phase motor for fans, blowers, oil burners, domestic laundry equipment, office appliances, or for general use wherever low-cost operation and quiet, smooth performance are required.

. . . quick starts under load, single phase? Answer the need for high starting torque with a General Electric Type KC capacitor-start motor. It's ideal for motorized tools, domestic water pumping, and commercial refrigeration.

. . . low speed? The wide range of General Electric fractional-horsepower motors also includes compact, easy-to-mount gear-motors (illustrated) for low-speed applications. In addition, there are unit-bearing motors for minimum maintenance, series motor parts for "built-in" power, and many definite-purpose motors.

***New!* An up-to-date fractional-hp motor review** In this booklet, of special interest to machinery manufacturers, you'll find described practically every standard G-E fractional-hp motor made. It contains helpful information on motor selection, operation and construction, plus a list of almost 40 bulletins covering detailed data on individual types. Send for it now — Bulletin GEA-5174.

GENERAL ELECTRIC

Digest

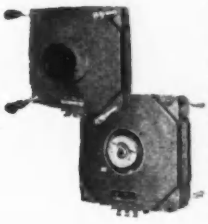
PRODUCT HIGHLIGHTS

KEEPS RECORDS

photoelectrically!

Direct currents, as well as temperature, speed, pressure, thickness, light and vibration can all be recorded with this versatile General Electric photoelectric recorder. Both the deflection and potentiometer types, using minimum energy, provide direct ink records for quick analysis. Sensitivities are as low as 1.0 microampere full scale, and responses as fast as ¼ second for full-scale deflection. For portable use or semi-flush mounting. See Bulletin GEC-254.

LETS YOU ADJUST SPEEDS



accurately!

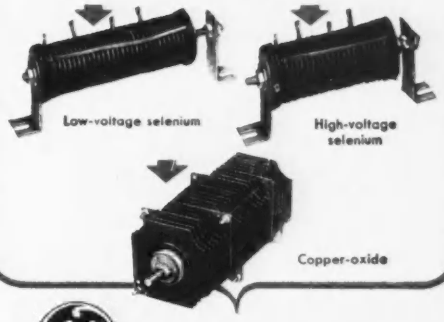
New! For speed control of d-c motors, or voltage control of generators and exciters, you'll want a General Electric plate-type field rheostat. Accuracy of adjustment is provided by many resistance divisions—27, 52, and 70 in the 6- 9- and 12-inch sizes respectively. Adjustable stops may be located at any position between ends of travel. Open (illustrated) and totally enclosed types are made for front or back-of-board mounting. See Bulletin GEC-487.

20-to-1 SPEED RANGE

in an a-c motor!

Here's a truly convenient adjustable-speed induction motor—the General Electric Tri-Clad Type ACA—that you can run on a-c without conversion equipment. A turn of the dial, and you get *any* speed over a range of 3 to 1, 6 to 1, or (for intermittent loads) even 20 to 1. And you can get it through remote control, too, with a flexible cable or pilot motor. Do you have possible applications for an adjustable-speed motor with these speed ranges? Write us for specific information, and check Bulletin GEA-4883.

WHEN A-C WON'T DO
choose one of these



METALLIC RECTIFIERS

Where you need small amounts of d-c—for example in electroplating, electrolysis protection, blocking relays in control circuits, circuit breaker operation, or power supply for magnetic chucks—get it conveniently from an a-c power source with a General Electric metallic rectifier. To fully meet your needs, General Electric makes all three types, each with special advantages for particular applications. A new, high-voltage selenium type is now available for use where high efficiency, uniformity and space economy are "musts." See Bulletin GEA-5280.

General Electric Company, Section G668-75
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

( ) **GEA-4883—Type ACA Tri-Clad Motor**
( ) **GEA-5174—Fractional-hp motors**
( ) **GEA-5280—High-voltage selenium rectifier**
( ) **GEC-254—Photoelectric recorder**
( ) **GEC-487—Plate-type field rheostat**

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

Name .....

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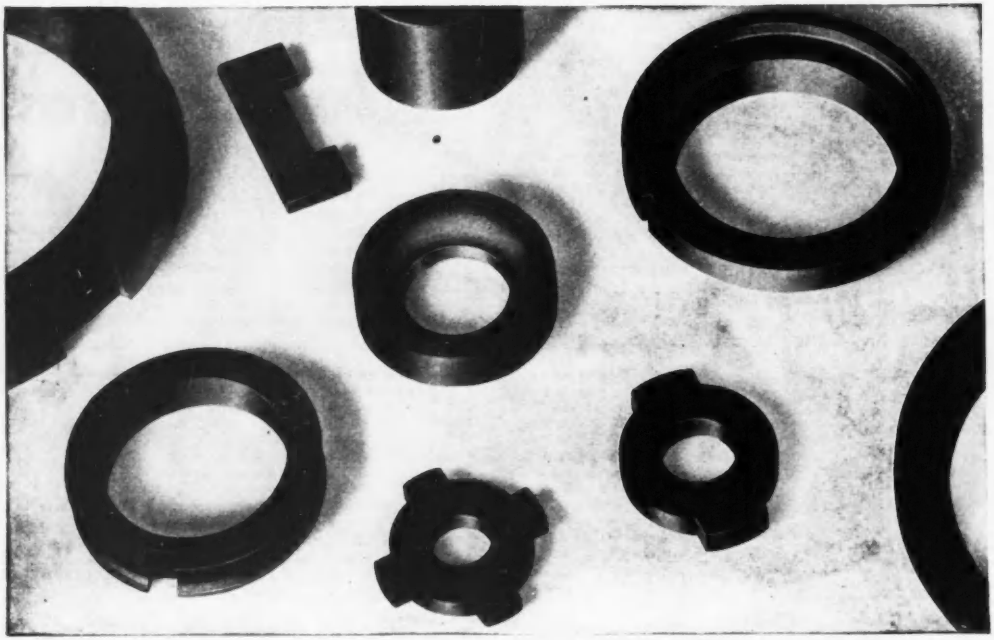
graphitar (Carbon-Graphite) pistons, piston of GARDNER-

The use of Graphitar at vitally important points is one of the reasons for the high operating efficiency and dependability of the Gardner-Denver Company air compressor. Because the piston, piston rings, and piston rod are Graphitar, the compressor needs no lubrication at these points and hence delivers compressed air that is entirely free of oil. Springs seated in grooves machined in the piston expand the Graphitar segmental piston rings to compensate for slight wear, assuring permanent effective sealing. The Graphitar packing rings also are segmented and contract under spring pressure to provide dependable sealing throughout constant use.

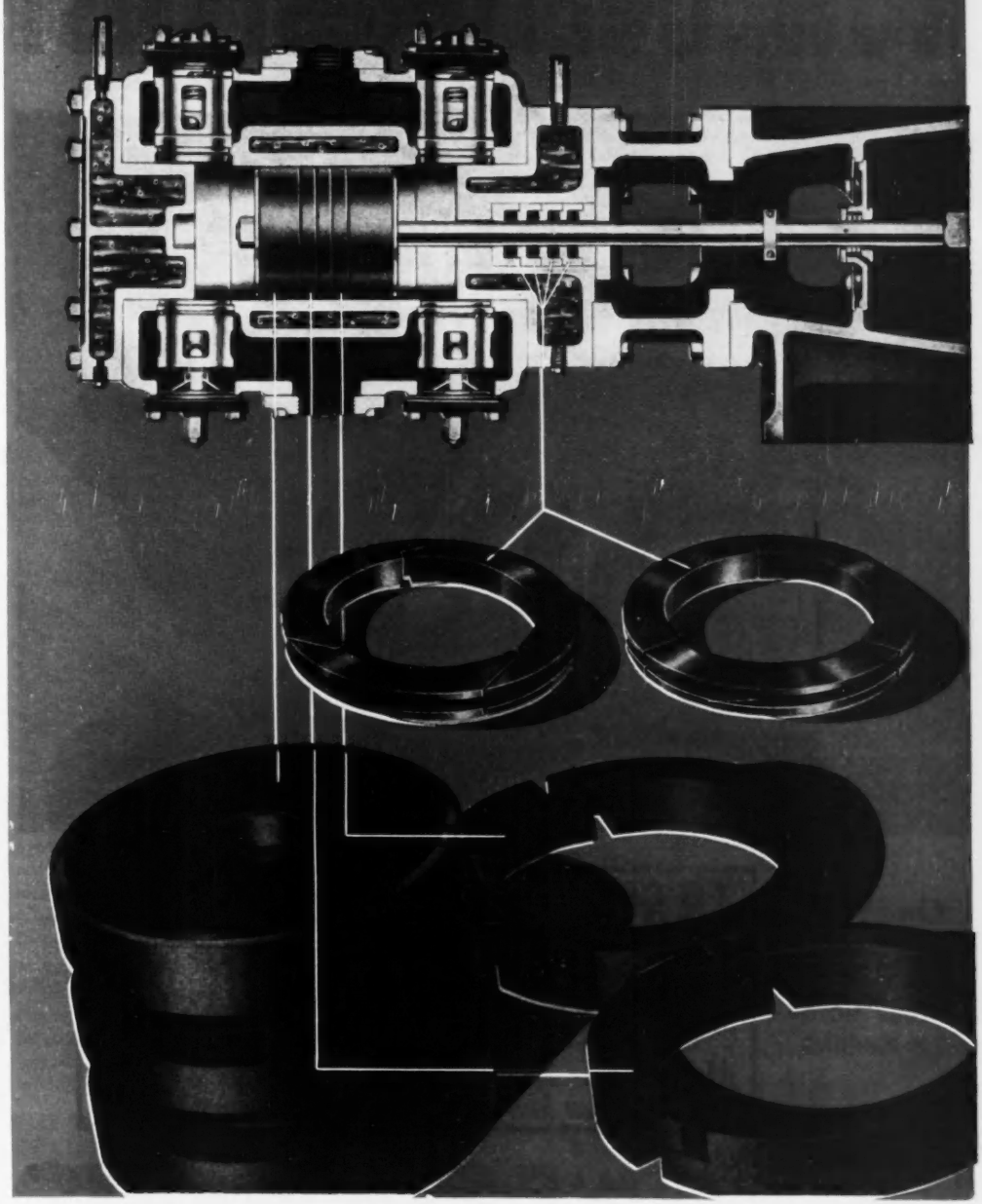
GRAPHITAR IS VERSATILE. Self-lubricating, light-weight, highly resistant to wear, temperature extremes and chemical attack, Graphitar is the ideal material for seals, rings, pistons, cylinder liners, and other parts in a wide variety of mechanisms. We are equipped to produce Graphitar parts in any practical size and shape. Tolerances may be as close as .0005" in small sizes. Send us sketches or descriptions of your products and our engineers will show you where Graphitar parts will improve mechanical performance and save you money. Write for new 64 page catalog just released.



THE UNITED STATES GRAPHITE COMPANY

rings and seals improve performance

DENVER air compressors



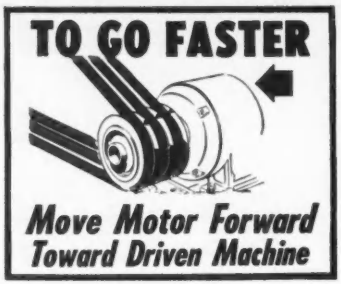
DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

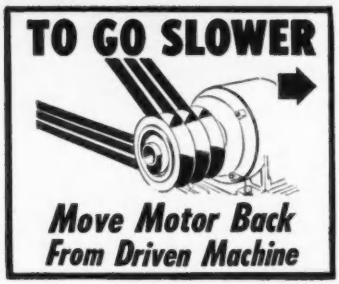
NEW TEXROPE AUTOMATIC SHEAVE

NOW.. Get Lowest Cost

One Hand
Does it...

WHILE MOTOR IS RUNNING





Originators of the Multiple V-Belt Drive for Industry!

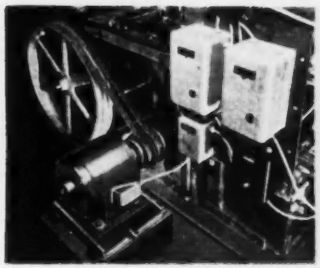
ALLIS

AIDS PRODUCT DESIGNERS

Instant Speed Control

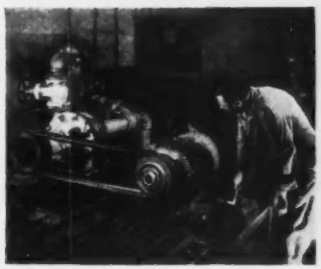
TEXTILE

AUTOMATIC SHEAVE changes speed of spinning frame in seconds while in motion. Replaces more expensive method of changing speed. Here, operator quickly obtains best operating speed to suit thread strength and size. Speed can also be changed to suit various operators.



WOOD PRODUCTS

CORING MACHINE uses automatic sheave and Allis-Chalmers induction motor and control. Instantly variable speed with 2 to 1 speed range greatly increases output at small original cost. Motor operates at 900 rpm with driven shaft speed adjustable from 120 to 228 rpm.



PUMPS

PERFECT SOLUTION to varying head and capacity of pump at same time maintaining efficiency. Where pumping requirements vary, pump can be instantly adjusted to supply more or less liquid as desired. Pump illustrated is solids handling pump driven by 10 hp enclosed motor.

MACHINE TOOLS

HIGH MACHINE PRODUCTIVITY is number one advantage of instantly adjustable Vari-Pitch Automatic drives. Constant cutting speed is now easily obtained at lowest cost for grinders, buffers and polishers . . . plus the inherent shock-absorbing advantages of Texrope V-Belts. Close control of periphery speed means higher efficiency grinding and polishing, as well as prolonged grinding wheel life.

Vari-Pitch Automatic Sheaves offer the same advantages for punch presses, engine and automatic lathes, drill presses and many other types of machine tools. Why not investigate the possibilities of using this new sheave in your product? You'll find an Allis-Chalmers Texrope drive expert at your nearby A-C Sales Office. He'll be glad to show you how Vari-Pitch Automatic Sheaves can be applied to your product.

NEW VARI-PITCH AUTOMATIC SHEAVE covers most speed changing needs from 3 to 40 horsepower . . . gives you instant *stepless* speed control for machines at lowest possible cost! It changes pitch diameter and holds belts at proper tension *automatically!* Gives you 100% speed increase; 2 to 1 range.

Machine designers and original equipment manufacturers are already using this new sheave to increase machine versatility . . . at costs only a fraction more than for other type of speed control.

Send for details on this great new advancement today. Learn how it can be applied to your problems at new lost cost. And for additional information on other A-C products for the OEM field — pumps, motors, controls, voltage regulators — check your needs in the coupon below.

Texrope and *Vari-Pitch* are Allis-Chalmers trademarks.

ALLIS-CHALMERS, 1002A SO. 70 ST. MILWAUKEE, WIS.

Please send me the literature checked below:

- Automatic Sheaves—Bulletin 2087223 ☐
- Handy Guide for Electric Motors — Bulletin 5186052 ☐
- Rocking Contact Voltage Regulators —
  - Bulletin 1386035 ☐
  - Bulletin 1486143 ☐
  - Bulletin 1486137 ☐
- Vari-Pitch Sheaves—Bulletin 2085082 ☐
- Speed Changers—Bulletin 2086013 ☐
- Switchgear and Control Devices — Bulletin 2587095 ☐
- Pre-Engineered Texrope Drives — Bulletin 2086956 ☐

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A-C ALLIS-CHALMERS

CHALMERS

EATON

Permanent Mold Gray Iron Castings

for VEE-BELT PULLEYS AND SHEAVES

- Uniform structure throughout the casting
- Freedom from growth and segregation
- Good tensile strength
- Ability to take high surface finish
- Free machinability

Eaton Foundry Division engineers will be glad to discuss the application of Eaton Permanent Mold Gray Iron Castings to your product. Send for the illustrated booklet, "A Quick Picture of the Eaton Permanent Mold Process for Producing Gray Iron Castings."

EATON MANUFACTURING COMPANY

CLEVELAND, OHIO

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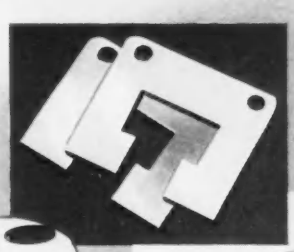
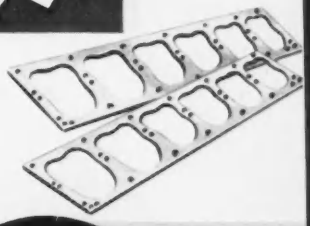
PRODUCTS: SODIUM COOLED, POPPET, AND FREE VALVES • TAPPETS • HYDRAULIC VALVE LIFTERS • VALVE SEAT INSERTS • ROTOR PUMPS • MOTOR TRUCK AXLES • PERMANENT MOLD GRAY IRON CASTINGS • HEATER-DEFROSTER UNITS • SNAP RINGS • SPRINGTITES SPRING WASHERS • COLD DRAWN STEEL • STAMPINGS • LEAF AND COIL SPRINGS • DYNAMATIC DRIVES, BRAKES, DYNAMOMETERS

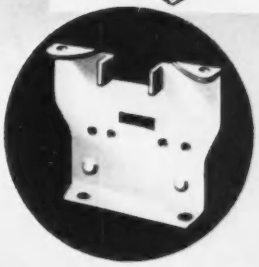
Weirzin

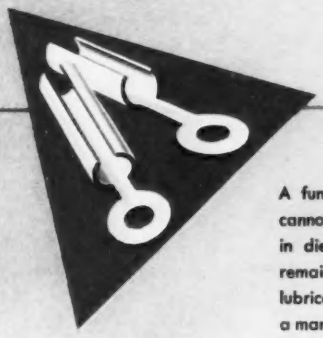
ELECTROLYTIC ZINC-COATED SHEETS AND STRIP





DIES LAST AND LAST . . .





A fundamental advantage possessed by Weirzin—one you cannot afford to ignore—is that it can effect important savings in die maintenance costs. Its tight electrolytic zinc coating remains intact in drawing operations, serving like a film of lubricant, to prolong the useful life of the dies. For example, a manufacturer reports that his usual production run of 100,000 pieces per set of dies, using ordinary carbon steel, was increased to 400,000 pieces when he adopted Weirzin.

Weirzin effects other appreciable savings in manufacturing, too. Sheets and coils require no pickling or buffing—and bonderized Weirzin products need no primer under paint.

WEIRTON STEEL CO.

WEIRTON, W. VA., *Sales Offices in Principal Cities*

Division of **NATIONAL STEEL CORPORATION,** Executive Offices, Pittsburgh, Pa.

se in "Suspense!"—CBS Radio Network
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DESIGN *for better living!*

• New beauty, convenience, economy has been made possible through the use of plastics and metal and plastic combinations. The modern automobile has demonstrated this great potential. And the broad scope of the varied applications is being repeated again and again throughout industry.

Here under one roof at Auto-Lite's great Bay Manufacturing Division in Bay City are the technical skills and production capacity for a new art rendered in plastics. The artistic skill of Auto-Lite's Art and Style Division is available on matters of design and development.

THE ELECTRIC AUTO-LITE COMPANY
Bay Manufacturing Division
723 New Center Bldg., Detroit 2, Michigan • Bay City, Michigan

Auto-Lite
plastics and metals

"For years I've bought machines of this type... but this is the first one I ever could

COUNT ON!"

Give your customers (and customers-you-hope) the thrill of discovery . . . of discovering something *new* in your product . . . something that gives them *new* advantages in use . . . *new* pride of ownership . . . *renewed* respect for you as a modern merchandiser!

How? Build a Veeder-Root Counter into your product. *But what kind of counter, and how to build it in?* Those are questions that a Veeder-Root engineer will answer promptly and squarely . . . if you let him concentrate his "mathematical eye" on your product.

And why let him do that? Because there are so many types of Veeder-Root Mechanical and Electrical Counters . . . and because so many of the most successful applications were not apparent at first, *at all*. Now, couldn't you *profit more* by having your product keep its own production records, prove its own service guarantee, protect customers against shortages and surpluses . . . or provide any of the many other new advantages that come with built-in Veeder-Root *Count*rol? It costs exactly 3 cents to find out. *Write.*

No. 1122 V-R Small Reset Ratchet Counter is built into a wide range of products from addressing machines and aerial cameras to hay balers, laundry machines, linotypes, shoe machinery, machine tools and — what have *you?* For a quick picture of the range of V-R Counters, send for free 8-page Condensed Catalog (shown). *Write now.*

Veeder-Root COUNTERS

VEEDER-ROOT INC., HARTFORD 2, CONNECTICUT

In Canada: Veeder-Root of Canada, Ltd., 955 St. James Street, Montreal 3. *In Great Britain:* Veeder-Root Ltd., Kilspindie Road, Dundee, Scotland.

Offer your customers lower production costs

with REEVES Speed Control

Yes, the "Honeymoon" is over. There's still plenty of business to be had—but the day is past when the date of delivery is more important than the quality of performance.

"What will be our production cost, per unit, with your machine?" is what the buyer wants to know—and *must know* to meet his own competition.

By equipping your machines with REEVES Speed Control, you enable your buyers to squeeze out every ounce of production that is inherent in the machine. The stepless, infinite speed adjustability, at the operator's command, enables him to fit the speed of the machine to variations in materials, to the kind, size and shape of products, to the number and skill of operators. Thus the machine does *more work, better work and at lower cost.*

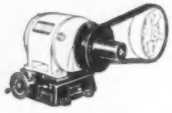
Working out the details of REEVES installations as standard equipment on your machines will be less troublesome than you expect. There's a REEVES factory-trained Speed Control engineer in your city or vicinity who will gladly work with you in selecting the right one of the many sizes of the three basic REEVES units, to meet your requirements.

Manufacturers of more than 2,100 different makes of machines serving a wide variety of industries, have adopted REEVES Speed Control as standard equipment. The nation-wide REEVES reputation, as the leader in this highly specialized field, plus the dependable performance of the 265,000 REEVES units in operation today, provides a valuable sales advantage to the machine builder.

Write for a free copy of our comprehensive catalog today and let us send a man to see you when you are ready. The catalog illustrates and describes many interesting standard equipment installations. Send for it today. Ask for catalog *K19-3N*

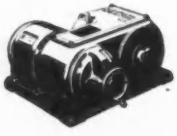
The Three Basic Reeves Speed Control Units

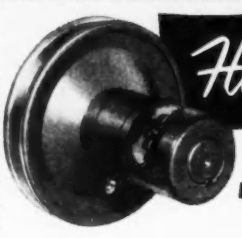
VARIABLE SPEED TRANSMISSION for providing infinite, accurate speed flexibility over a wide range—2:1 to 16:1. Sizes—fractional to 87 hp.



VARI-SPEED MOTOR PULLEY provides an instantly variable speed drive within 4:1 ratio for any constant speed motor. Sizes to 10 hp.

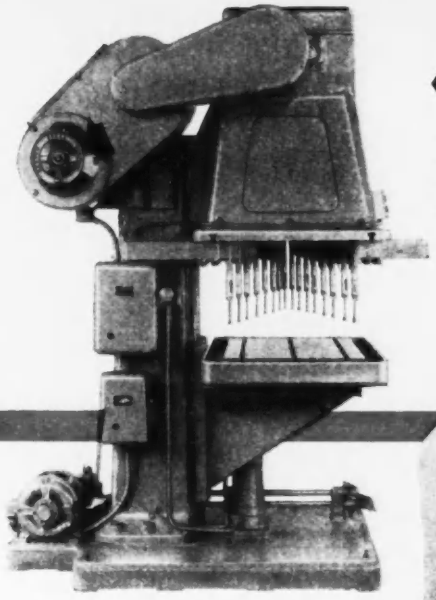
MOTODRIVE combines motor, speed varying mechanism and reduction gears in single unit. Speed variations 2:1 to 6:1 inclusive. Sizes to 20 hp.





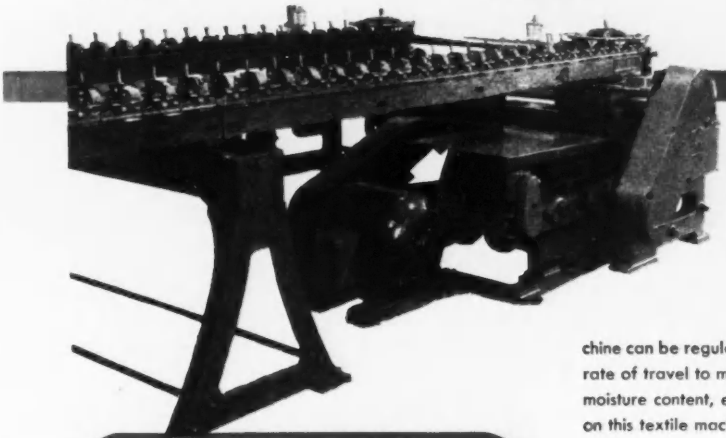
Latest REEVES unit for your Light Machinery

Now, at extremely small expense, you can equip your lightest machines with genuine REEVES Speed Control. Easy to install and simple to operate, REEVES Vari-Speed Jr. provides dependable, accurate, infinitely variable speed control within the range of 1¾:1 to 2¾:1 using any constant speed motor from fractional to 1½ hp. Ask for special bulletin No. K19V-4912.



Adapted to meet operational requirements and to permit modern streamlining of the machine, the No. 6000 internal working parts of the REEVES Motodrive are installed as standard equipment on this ROOT F400, hood type multiple metal driller. Simply by turning the REEVES handwheel, the operator obtains any variation of spindle speed from 550 to 2500 rpm, for best results with kind and thickness of metal being worked, and size of drills.

The combined use of a REEVES Vari-Speed Motor Pulley, reducer and clutch brake provides the high acceleration upset force and deceleration required for flash welding of aluminum with this PROGRESSIVE welder. Machine controls are automatic, with stepless adjustment over a wide range. Note the compact space-saving REEVES installation within the framework of the machine, as shown in the detail drawing.



Pictured at left is a new VAN VLAANDEREN Tenter Frame which utilizes a No. 3 Horizontal open REEVES Transmission, as standard equipment, to provide instantly and infinitely variable speed adjustability. Thus the speed of the machine can be regulated, accurately, to provide the correct rate of travel to match such variables as weight of cloth, moisture content, etc., of material being tented or dried on this textile machine.

ACCURATE • VARIABLE

Reeves Speed Control

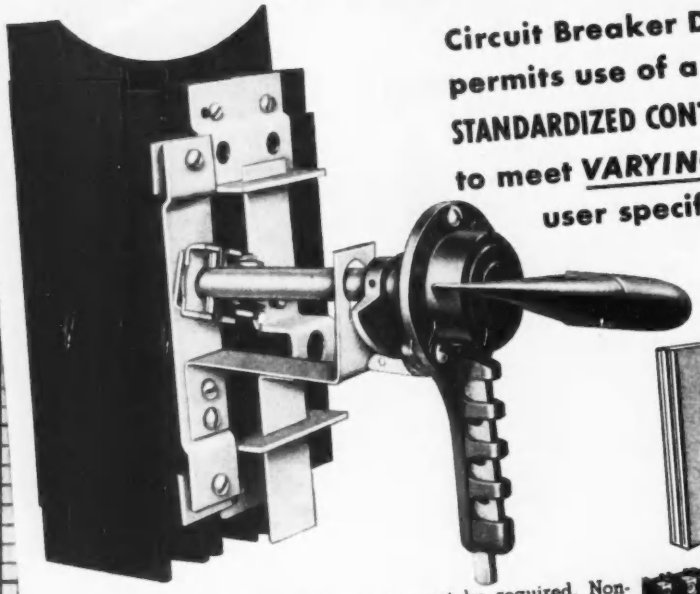
GIVES THE RIGHT SPEED FOR EVERY JOB!

REEVES PULLEY COMPANY

COLUMBUS, INDIANA • *Recognized Leader in the Specialized Field of Speed Control Engineering*

Now... a PRACTICAL DISCONNECT

Circuit Breaker Disconnect permits use of a STANDARDIZED CONTROL PANEL LAYOUT to meet *VARYING* user specifications

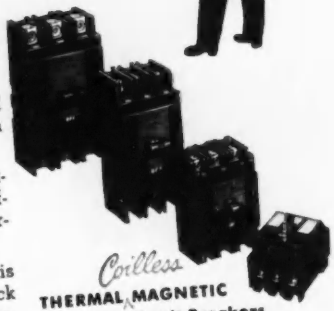


CIRCUIT PROTECTION may or may not be required. Non-automatic circuit interruptors and automatic circuit breakers of equivalent ratings have identical dimensions.

COMPACT MECHANISM has electrical parts totally enclosed in molded insulation case. Space required is same for both 250 and 600 Volts.

CONVENIENT MOUNTING. Disconnect device mounts directly on control panel without use of brackets or posts. Self-aligning coupling rod of proper length engages separate operating handle assembly on door.

SAFE. Interlock prevents opening door when disconnect is "ON". Authorized person with tool can release door interlock for inspection without power interruption. When door is reclosed, self-aligning handle indicates true position of disconnect. Operating handle can be locked "ON" or "OFF" with one, two, three or four padlocks of varying sizes. Handle locking mechanism also locks door.



Coilless

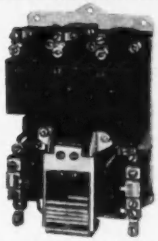
THERMAL MAGNETIC ML Series Circuit Breakers are non-tamperable, give repeat protection, and can be quickly reset by anyone. Non-automatic circuit interruptors of equivalent sizes also available.

SQUARE D COMPANY

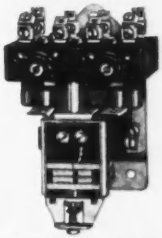
DETROIT · MILWAUKEE · LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

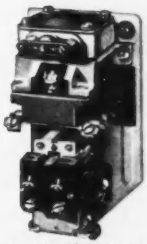
for MACHINE TOOL CONTROL



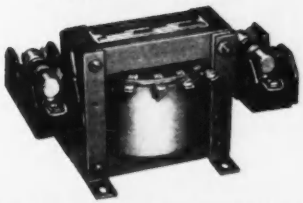
MAGNETIC STARTERS



CONTROL RELAYS

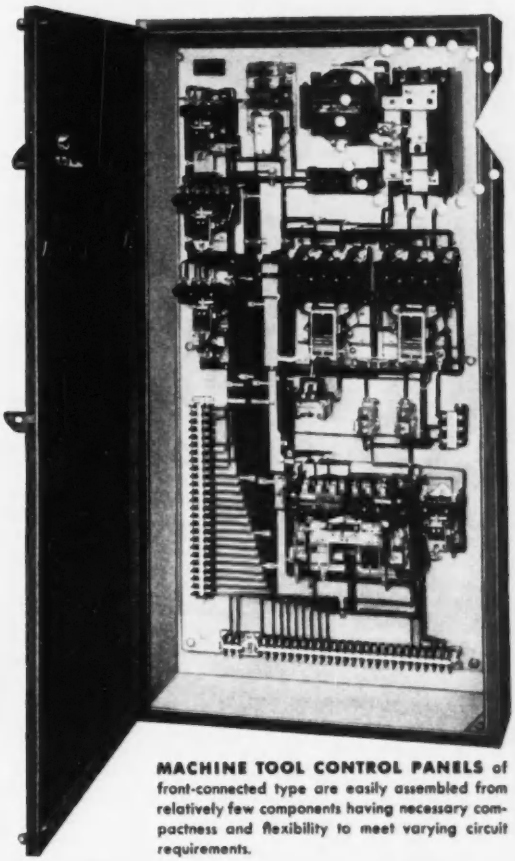


PNEUMATIC TIMERS



CONTROL CIRCUIT TRANSFORMERS

Completes a Line of Control Devices Designed *Specifically* for Machinery Applications



MACHINE TOOL CONTROL PANELS of front-connected type are easily assembled from relatively few components having necessary compactness and flexibility to meet varying circuit requirements.

Write for Bulletin 2420 ML. Square D Company, 4041 N. Richards Street, Milwaukee 12, Wisconsin

You Can Avoid Motor Burnouts

...by using motors with

KLIXON

MOTOR PROTECTORS

There is *no* need to put up with motor burnouts in your equipment especially when *you can prevent* this major headache simply and at surprisingly low cost.

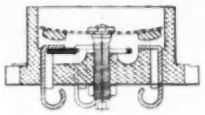
Here's all you need do . . . when you buy motors *specify that they have built-in Klixon Motor Protectors.*

These simple, foolproof protectors take into account the factors that cause motors to overheat and burn out and shut the power "off" should they become dangerously overheated. Then when they cool to a safe operating temperature, they snap the power "on" again automatically or by pushing the reset button, depending on the type of protector used.

Klixon Protectors are unaffected by vibration, motion or shock. Harmless overloads of short duration do not cause nuisance tripouts. Protect your motors and other electrical equipment, such as transformers, solenoids, adjustable transformers, from burning out . . . specify equipment with built-in Klixon Protectors.

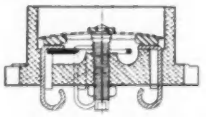
Illustrated below are a number of typical Klixon Protectors

HERE'S HOW THEY OPERATE



CLICK...IT'S OFF!

When temperature within the equipment reaches the danger point, the Klixon Protector snaps the power "off" preventing burnouts.



CLICK...IT'S ON!

When the equipment cools to safety, the Klixon Protector snaps the power "on" automatically when the automatic reset type is used . . . or by pushing the reset button when manual reset type is used!

KLIXON

SPENCER THERMOSTAT

Division of Metals & Controls Corp.

909 FOREST STREET, ATTLEBORO, MASS.

"A BOLT IS ONLY HALF A FASTENER WITHOUT A NUT!"

FOR A *Complete* QUALITY "FASTENER TEAM" USE LAMSON NUTS!

It takes *two* to complete a "fastener team"... a bolt and a nut. Quality bolts *deserve* the plus values found in Lamson nuts ... the accurate fit and dependable holding power.

Lamson makes many different types of nuts in hundreds of shapes, styles and sizes ... a nut for almost every purpose.

Whether you need standards or specials, in plain, plated or stainless steel—in brass, bronze or aluminum, Lamson makes them all.

Think of Lamson nuts when you buy bolts ... and buy *both!*

THE LAMSON & SESSIONS COMPANY

General Offices: 1971 West 85th Street, Cleveland 2, Ohio

Plants at Cleveland and Kent, Ohio • Chicago • Birmingham

Lamson & Sessions

"One Responsible Source for All Fastener Needs"

SEMS	LOCK NUTS	NUTS	STUDS
STOVE BOLTS	LAG BOLTS	WASHERS	RIVETS
TAPPING SCREWS	ROPE CLIPS	SET SCREWS	PLOW BOLTS
"1035" CAP SCREWS	MACHINE BOLTS	CARRIAGE BOLTS	COTTER PINS

WANT MORE INFORMATION on any of these fasteners? CHECK—and CLIP this strip.

LAMSON LOCK NUTS: Economical, vibration-proof. Can be re-used repeatedly.

SEMS: Tapping and Machine Screws with Lockwashers attached.

COTTER PINS: Steel, Brass, Aluminum and Stainless Steel.

"BENT" BOLTS: Including U Bolts, Eye Bolts, Hook Bolts, etc.

LOK-THREAD STUDS: Thread locks and seals in standard tapped holes.

Wire Rope Clips: Hi-Center saddles, extra-strength U Bolts.

PLASTIC INSERTS: To your specifications ... in production quantities.

AIRCRAFT FASTENERS: AN Bolts, Nuts, Screws, Studs and Cotters.

"1035" CAP SCREWS: Hi-Tensile heat-treated steel.

The Lamson & Sessions Company
1971 W. 85th St., Cleveland 2, Ohio

NAME

POSITION

COMPANY

STREET

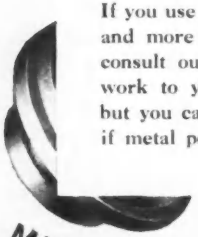
CITY ZONE STATE

—CUT ALONG THIS LINE—

Over and over, we have declared that Moraine will accept orders for metal powder parts only when we are dead certain that the purchaser will benefit—through savings in costs, or through improved performance. Our purpose has been not to discourage inquiries but, rather, to attract them . . . by assuring you that, if we accept your order, the results will be to your advantage.

Actually, the basic requirements for metal powder manufacture are plain and simple. The shape must permit good die fill and proper density . . . the required physical properties and tolerances must be within the range obtainable by normal production methods . . . and the quantity ordered must be sufficient to justify the initial tooling costs.

If you use quantities of parts which you think *might* be made better and more economically by powder metallurgy, don't hesitate to consult our engineers. If they determine that the process would work to your advantage, as well as to ours, they will tell you; but you can depend on them to say "No," politely and regretfully, if metal powder parts are not for you.



METAL POWDER PARTS BY MORAINE

MORAINE PRODUCTS

DIVISION OF GENERAL MOTORS, DAYTON, OHIO

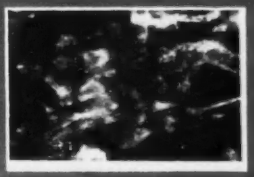
NATIONAL OIL SEAL LOGBOOK

LEATHER vs. RUBBER OIL SEALS

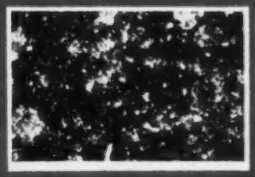
Which is better? And when?

There has been much controversy during the past ten years on the relative merits of leather vs. synthetic rubber for use in oil seals. In considering this subject, it should be remembered that performance of leather oil seals is limited to the inherent capabilities of the leather itself as a raw material, even granting improvements gained through various impregnation tanning and finishing processes. Synthetic rubber, on the other hand, can be especially compounded for the job, and is immune to many industrial chemicals which would deteriorate leather. Nevertheless, there is a place for both materials in the picture.

PHOTOMICROGRAPHS SHOW INHERENT DIFFERENCES



LEATHER magnified to 500 diameters shows porosity which will absorb fluids. Leather sealing members are more practical and economical for use on high shafts in which otherwise suspensions which operate at slower speeds, where torque is not a factor, or where seal may be lubeobserved or operate intermittently dry.



SYNTHETIC RUBBER magnified to 500 diameters shows a very solid nonporous mass. Sealing members of synthetic rubber will provide superior performance on any dynamic lubricant application, particularly where temperatures are over 200° F., speeds over 2,000 f.p.m. or run-out over .005 indicator reading.

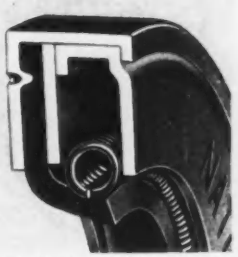
Given fine tolerance designing, expert manufacture and mirror-bright shaft finishes, either rubber or leather oil seals will perform well; but when machinery must be designed to broad tolerances and finishing is relatively rough, leather seals are generally more practical. Because leather sealing members are more resistant to abuse, they are recommended when service conditions are inexpert, particularly where lubrication is apt to be neglected. When utilizing leather seals, the designer should consider the relatively greater torque.

Fundamentally, synthetic rubber oil seals are more resilient, withstand higher temperatures and create considerably less drag, while forming a near-perfect closure around moving shafts. Where torque is a factor and high speeds are encountered—where run-out, shaft whip or eccentricity are extreme—where the machine is unusual or intricate—rubber seals are ideal.

In National Oil Seals, leather sealing members have been "Nationalized", a process which helps leather retain precise shape and size and also withstand heat. National synthetic rubber oil seals employ "Syntech*", which is specially compounded for use in seals.

National engineers are at your service to help you solve any oil sealing problem. For further information please contact nearest office.

In some applications it is good practice to use both leather and rubber oil seals—either separately or in combination—such as shown in the dual wipe seal at left.



National spring-loaded leather seal

National spring-loaded Syntech* rubber seal

NATIONAL
OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, Calif.
Plants: Redwood City and Los Angeles, Calif.; Van Wert, Ohio

Syntech is the registered trademark for the National synthetic rubber compound.

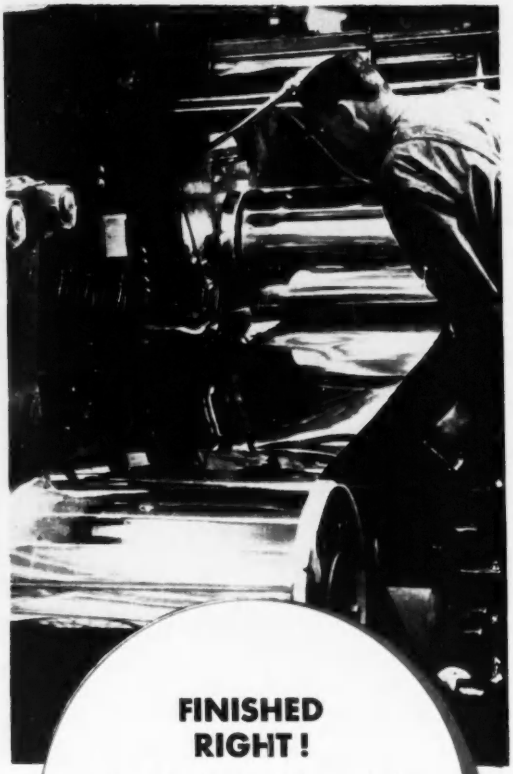
1568

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

BUFFALO: 56 Arlington Place, Grant 2280.
CHICAGO: Room 2014 Field Building, Central 6-8663.
CLEVELAND: 210 Heights Rockefeller Bldg., Yellowstone 2720.
DALLAS: 30½ Highland Park Village, Justin 8-8453.
DETROIT: Room 1026 Fisher Building, Trinity 1-6363.
HOUSTON: 6731 Harrisburg Boulevard, Wayside 3-1246.
LOS ANGELES: 2244 East 37th Street, Kimball 6384.
MILWAUKEE: 647 West Virginia St., Marquette 8-8986.
NEW YORK CITY: 122 East 42nd Street, Lexington 2-8260.
PHILADELPHIA: 401 North Broad Street, Bell-Walnut 2-6997.
REDWOOD CITY, CALIF.: Broadway and National, Emerson 6-3861.
WEST SPRINGFIELD, MASS.: 1025 Elm Street, Springfield 2-1881.
EAST SYRACUSE, N. Y.: 226 Raby Avenue, East Syracuse 366.
WICHITA: 340 North St. Francis Ave., Wichita 2-6971.

Reprints from this or other Logbook pages are available for your files. Request them from our Redwood City, California, office

3 important reasons why so many "If you use strip steel



MANUFACTURED RIGHT!

Because Amerstrip is carefully and uniformly rolled, you can easily fabricate dependable parts that are light in weight . . . completely accurate in size . . . and that are low in cost, yet high in quality.

FINISHED RIGHT!

You can get Amerstrip in the exact finish you want. For our finishing equipment, which is generally regarded as the finest in the country, can produce strip with *all* commercial bright finishes. These smooth, satiny finishes are certain to add a big "extra" to any product whose eye appeal is largely responsible for its sales appeal.

manufacturers will tell you—

...use Amerstrip"

■ Ask the product manufacturers—the fellows who are now making their products in part or in their entirety of U·S·S Amerstrip and you'll probably hear 3 reasons why they switched from other metals. Amerstrip's manufacture. Amerstrip's finish. Amerstrip's packaging.

So why not give some thought to using Amerstrip in *your* product? If you need a metal that is available in a complete range of edges, tempers, finishes and widths . . . that will form easily . . . that will give excellent results in high-speed, continuous operations . . . that can *always* be depended upon for never-varying quality—specify Amerstrip!

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

PACKAGED RIGHT!

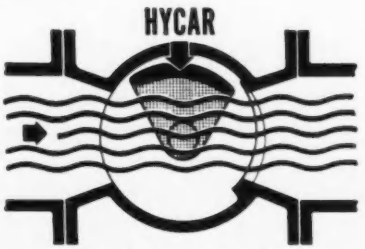
There's never a worry about damage in transit when you order a shipment of Amerstrip! For packaging is given the same careful attention as production. The strip is fastened securely to a wooden pallet by strong, steel bands, so that bumps on rough roads or swaying of fast freights won't cause any damage.

USS

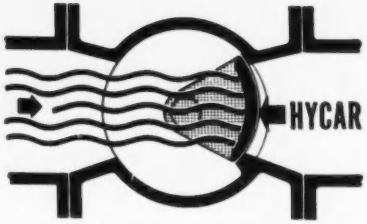
AMERSTRIP

UNITED STATES STEEL

DeZurik Easy Operating Plug Valve, DeZurik Shower Co., Sartell, Minn.



Valve Open. The eccentric lifts the plug face from all contact with the seat. Line pressures cannot distort or stretch the metal-cored rubber sealing member. Merely a quarter-turn of the lever establishes full-open flow.



Valve Closed. The resilient, Hycar face of the plug makes drip-tight contact with the seat in the body. Perfect closure is insured even when flow includes rust, scale, sand, abrasives or foreign matter.

Flow control valve with a leak-proof "heart"

THE valve you see here insures a drip-tight shut-off for gases or liquids, vitally important in many processes. It is absolutely leak-proof even when the flow includes rust, scale, abrasives or foreign matter.

Here's the "secret." An exclusive eccentric principle releases the face of the valve from all contact with the seat, except when the valve is closed. The "heart" of the valve—the plug—is faced with Hycar providing the leak-proof closure, the valve's big feature.

Hycar was chosen because of its resilience and its resistance to the widest range of chemical and petroleum products. Hycar can be bonded to the metal, which is necessary in molding to the core. Equally important, Hycar resists dimensional changes and has minimum cold flow under load.

Perhaps Hycar can solve a problem for you, or improve a product. Hycar is oil-and-gas-resistant, light in weight. It resists heat, cold and aging. It has high tensile strength, good resilience and extreme resistance to abrasion. Compounds can be varied from extremely soft to bone hard, and made in many colors.

Versatile Hycar is used as a rubber base material . . . as a plasticizer for vinyl resins . . . as a modifier for phenolics . . . as an adhesive base . . . as a latex for coating or impregnating. Find out how it may help you, profitably. Please write Dept. HJ-9, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

Hycar

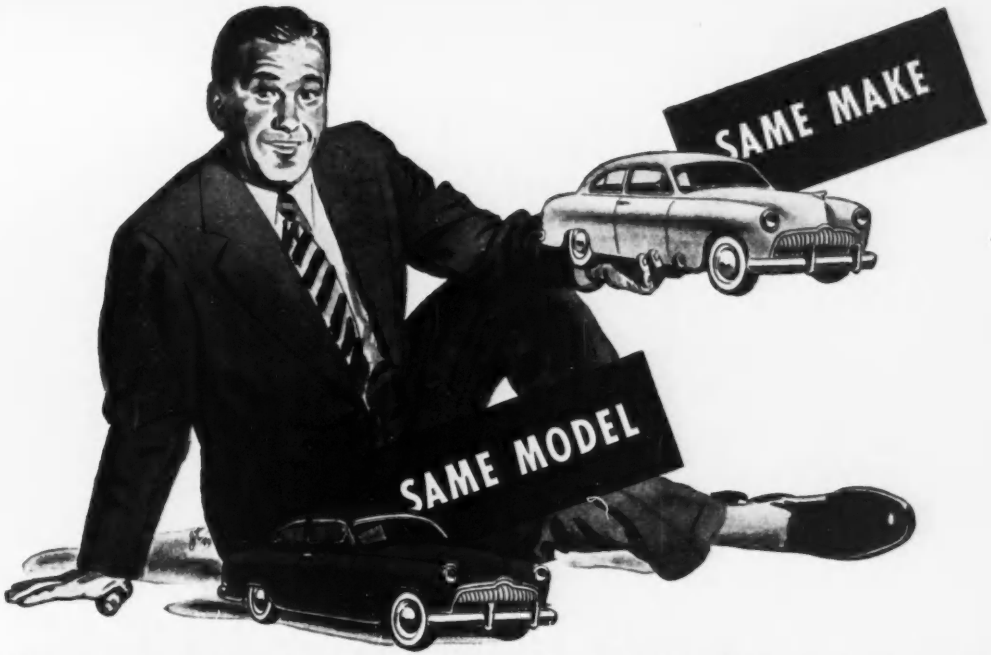
Reg. U. S. Pat. Off.

American Rubber

B. F. Goodrich Chemical Company

A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers



YET IN ONE, 30 POUNDS OF ALUMINUM DOES THE WORK OF 75 POUNDS OF STEEL*

Seeing these two autos speeding down the highway you couldn't tell them apart. Yet one is lighter, built better, will operate for less. The maker uses 30 pounds of aluminum where he once required 75 pounds of steel. He eliminates rust hazard and gives his customers eye-catching finishes that stay attractive through years of use.

Company executives have found the true cost of aluminum is finished cost in their product. Right from the start you get three times more metal to work with when you use aluminum instead of steel or other common metals. There's less weight to ship both coming and going. Many die maintenance problems are ended. Production figures show aluminum is easier to work. Sales figures show consumers appreciate aluminum's advantages.

Today aluminum is a whole family of metals. And Reynolds *Lifetime* Aluminum is available in many forms to serve you best: pig, ingot, sheet, plate, wire, rod, bar, screw machine stock, pipe, tubing, structurals and extrusions. With them you also get the assistance of Reynolds technical service department on product redesign and production.

Beat competition to market with improved, lower cost aluminum designs. Call the nearby Reynolds Field Office or Distributor, listed under "Aluminum" in your classified phone directory. Or write direct to Reynolds Metals Company, Aluminum Division, 2524 South Third Street, Louisville 1, Kentucky.

REYNOLDS ALLOY DATA BOOK

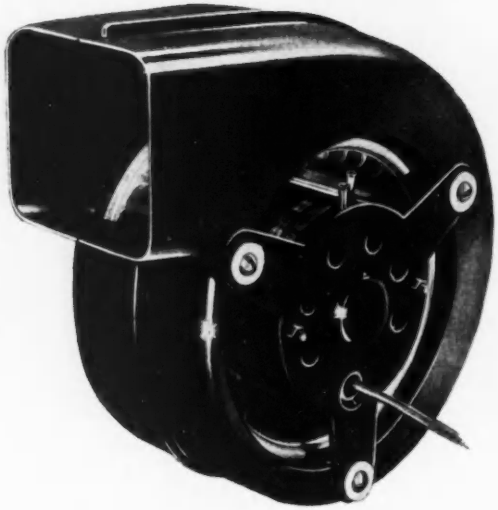
A 162-page book with complete data on aluminum alloys and mill products. Free when requested on your company letterhead.

*Verified report from a major auto maker.

REYNOLDS
***Lifetime* ALUMINUM**

CONSIDER ALUMINUM—CONSULT REYNOLDS—THE COMPLETE ALUMINUM SERVICE

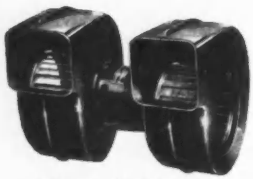
built-in DEPENDABILITY



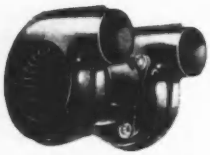
MODEL 3802
This compact motor-in-wheel A.C. blower unit delivers 100 Cubic feet per minute

Redmond MICROMOTOR BLOWER UNITS

MODEL 3866 A.C.
150 C.F.M.



MODEL 3901 A.C.
220 C.F.M.



MODEL 3744 A.C.
100 C.F.M.

Here's the solution to your small-blower problems . . . choose a Redmond Micromotor Blower Unit. Compact, sturdy, and thoroughly dependable, these units are built to give long-lasting satisfaction. Precision balancing of all moving parts minimizes vibration, assures quiet operation.

Each unit is powered with a Redmond Micromotor, famous for its ability to perform smoothly and quietly over thousands of hours of continuous duty.

A.C. blowers available in capacities from 50 C.F.M. to 220 C.F.M.; D.C. blowers up to 125 C.F.M. Single or double outlet. Outlet mounting flanges and inlet screens also available. Write for catalog.

Redmond COMPANY, INC.
OWOSSO, MICHIGAN
OFFICES IN NEW YORK, CHICAGO, LOS ANGELES, DALLAS
Expanded Facilities • Prompt Deliveries • Service before and beyond the sale

REDMOND ®

MOLDED IN PLASTICS BY GENERAL ELECTRIC

Paper cup dispenser, molded by General Electric for the Dixie Cup Company, Easton, Pa.

LOWER SELLING PRICE! The use of G-E plastics (instead of wood) for this television cabinet helps to make possible a low-priced set.
LARGE-VOLUME JOBS! G. E. is ideally equipped to mold large-quantity jobs—like parts for the Ocean City Manufacturing Co.'s surf casting reel.
PLASTICS FOR DISPLAY! The attractive housing of this Spur syrup dispenser was molded by G. E. for Canada Dry.
Spur
Plastics

How G-E Plastics Help to LOWER PRODUCT COSTS

Here's an excellent example of how General Electric's plastics molding service helped to achieve improved design and *low costs* on a large-volume job.

G. E.'s customer, the Dixie Cup Company, wanted an attractive cup holder—sanitary, durable, yet inexpensive enough to be sold for home as well as office use. They got it! General Electric molded this cleverly-designed unit of crystal-clear polystyrene; no metal dispensing parts are needed. And low-cost production made possible a low retail price which is attracting thousands of customers.

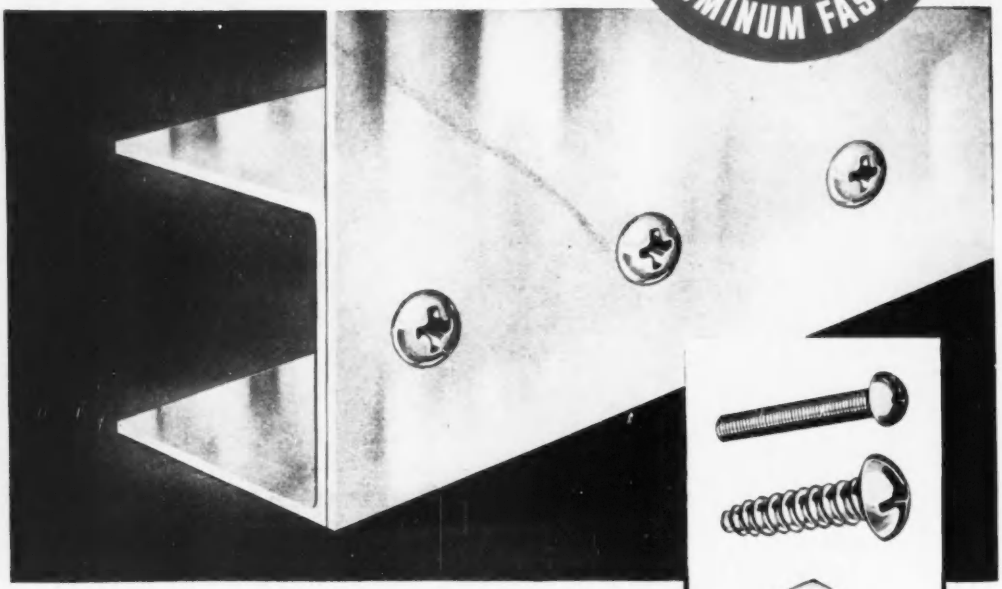
For low cost and high quality depend on General Electric's plastics service! One of the world's largest plastics molders, G. E. is ideally equipped for large-volume production. WRITE US FOR MORE INFORMATION on how this service can work for you. Or contact your nearest G-E sales office. Address: Plastics Division, Chemical Department, General Electric Company, 1 Plastics Avenue, Pittsfield, Mass.

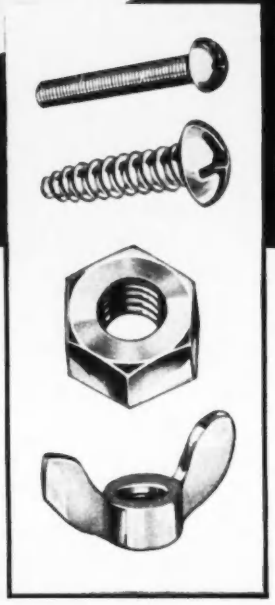
GENERAL ELECTRIC

CD49-A44

General Electric plastics factories are located in Coshocton, Ohio; Decatur, Ill.; Taunton and Pittsfield, Mass.

THE JOINTS STAY TIGHT WHEN YOU





Use Alcoa Aluminum Sheet Metal Screws

Use of Alcoa Aluminum Fasteners will prevent galvanic corrosion that can result when dissimilar metal screws are used to fasten aluminum assemblies. They help joints stay strong and tight.

Alcoa Fasteners resist common corrosion, too—won't rust red or stain adjacent surfaces. And their low cost will amaze you.

Now available with Phillips heads, for fast, slip-free driving; sheet metal, wood and machine screws, standard sizes and lengths, in all popular head types. Other Alcoa Fasteners, too—hex head bolts, washers, hex nuts, cap nuts, wing nuts, castle nuts, in standard sizes and threads. ALUMINUM COMPANY OF AMERICA, 618J Gulf Building, Pittsburgh 19, Pennsylvania.

WRITE FOR FREE SAMPLES—Samples of Alcoa Aluminum Fasteners sent free when you request them on your letterhead. Please specify the type and size you'd like.

ALCOA *Aluminum* FASTENERS

ALCOA ALUMINUM

INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS
ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

Edge Lighted Sign. Molded for Roger M. English & Associates, Chicago

Plastics Produces a Sure Sign of Salesmanship

Write on your letterhead for the new Injection Molded and Extruded Plastics Catalog. Or, for detailed information about [redacted], piping, tubing and fittings, write for circulars containing data and illustrations.*

** Trademark Registered*

Put a sign in a store window and watch the customers gather—that is, if the sign is this one which we molded for Roger M. English & Associates, Chicago. Producing eye appealing displays such as this is but one phase of our many sided plastics molding skill.

Whether yours is a product for rugged industrial use—or an exquisitely styled feminine object—we can mold it to your greater satisfaction in our ultra-modern new plant. What's more, our precision craftsmanship and proper use of correct plastic materials assures you of better plastic products.

Our greater new facilities backed by richly varied molding experience are at your service. Let us help you solve your plastic problems without obligation.

NEW PLANT | NEW ADDRESS

ELMER E. MILLS CORPORATION

INJECTION MOLDERS and EXTRUDERS of: Tenite, Lumarith, Plastacele, Lucite, Nylon, Ethyl Cellulose, Plexiglas, Polystyrene, Styron, Loalin, Vinylite, Geon, Plexene, Polyethylene, Cerex, Forticel, [redacted]*, Saran, and other Thermoplastic Materials.

2930 NORTH ASHLAND AVENUE • CHICAGO 13, ILLINOIS

UNBRAKO

SOCKET CAP SCREW WITH KNURLED HEAD

...SLIP-PROOF HEAD
...EXTRA STRONG
...MADE TO CLOSE TOLERANCES

There is a definite saving of assembly time when you use "UNBRAKO" Socket Head Cap Screws with Knurled Heads. The exclusive knurled heads perform a triple duty: (1) the *knurling* provides a sure, slip-proof grip; (2) the *knurling* permits positive locking—a feature so often essential where there is excessive impact or vibration; (3) the *knurling* speeds assembly, because it enables the "UNBRAKO" to be screwed in easier, faster, and further with the fingers—handiest of all wrenches—before a "key" becomes necessary.

Knurling of Socket Screws originated with "Unbrako" in 1934.

As always, the name of "UNBRAKO" signifies *extra strength* and *precision manufacture to close tolerances.*

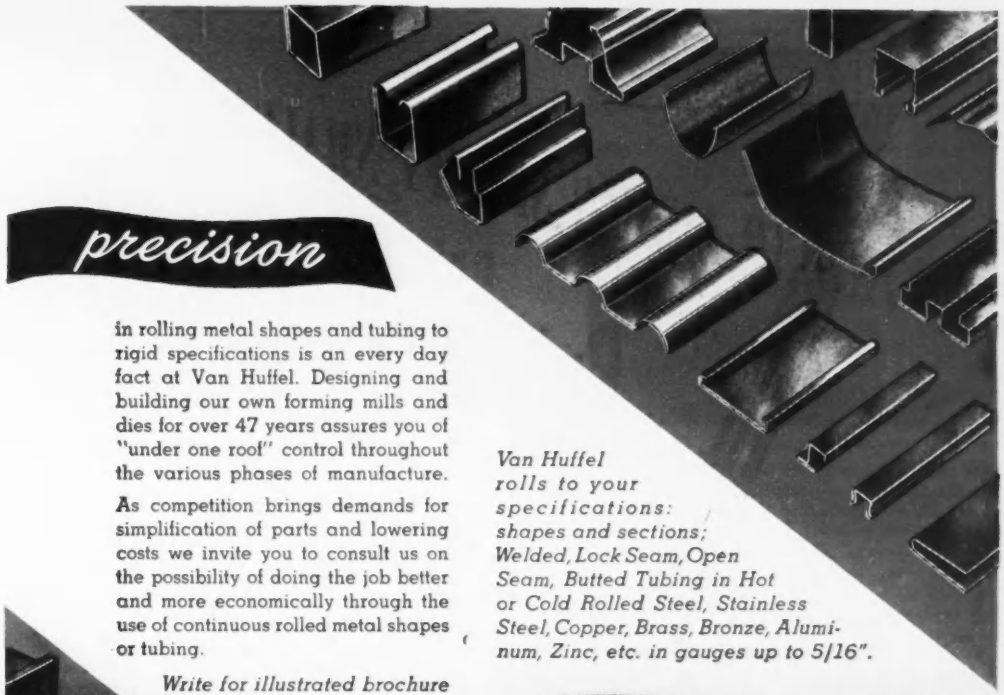
"UNBRAKO" Knurled Socket Head Cap Screws are available in sizes from # 4 to 1½" diameter, and in a full range of lengths. Write for your free copy of the "UNBRAKO" Catalog and the name of your nearest "UNBRAKO" Distributor.

Other "UNBRAKO" Products include:
Socket Set Screws with Knurled Cup Points, Socket Set Screws with Knurled Threads, Square Head Set Screws with Knurled Cup Points—all patented, self-locking screws that won't shake loose! Socket Head Stripper Bolts. *Precision-Ground* Dowel Pins. *Fully-Formed* Pressure Plugs.

SPS **STANDARD PRESSED STEEL CO.**

BOX 545 JENKINTOWN, PENNSYLVANIA

"Serving Industry continuously since 1903 through Industrial Distributors"



precision

in rolling metal shapes and tubing to rigid specifications is an every day fact at Van Huffel. Designing and building our own forming mills and dies for over 47 years assures you of "under one roof" control throughout the various phases of manufacture.

As competition brings demands for simplification of parts and lowering costs we invite you to consult us on the possibility of doing the job better and more economically through the use of continuous rolled metal shapes or tubing.

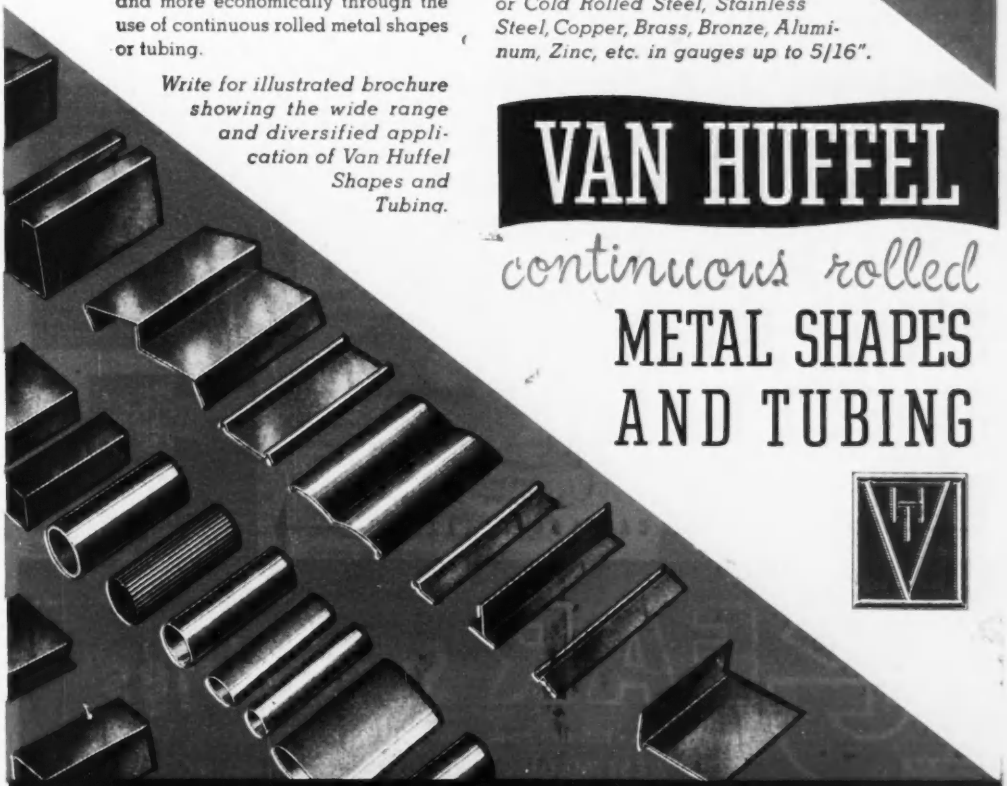
Write for illustrated brochure showing the wide range and diversified application of Van Huffel Shapes and Tubing.

Van Huffel rolls to your specifications: shapes and sections; Welded, Lock Seam, Open Seam, Butted Tubing in Hot or Cold Rolled Steel, Stainless Steel, Copper, Brass, Bronze, Aluminum, Zinc, etc. in gauges up to 5/16".

VAN HUFFEL

continuous rolled

METAL SHAPES AND TUBING



VAN HUFFEL TUBE CORPORATION · WARREN · OHIO

PARTICULAR BUYERS SPECIFY SMALL GEARS BY

FRACTIONAL HORSEPOWER GEARING

The REGINA ELECTRIC POLISHER

THE Regina Corporation of Rahway, New Jersey, depends upon G.S. Fractional Horsepower Gearing for their Regina Electric Polisher. Like so many of America's critical buyers, they insist upon close adherence to exacting specifications, plus a high degree of *uniformity* in the Gears they use. If smoother, quieter performance and longer life are important factors in the products *you* make, by all means Specify "G.S." Small Gearing next time you buy. Here you'll get all the specialized "Know How" only 30 years of experience can give . . 30 years of developing, perfecting, and GROWING into the "World's largest manufacturers of Fractional Horsepower Gearing!"

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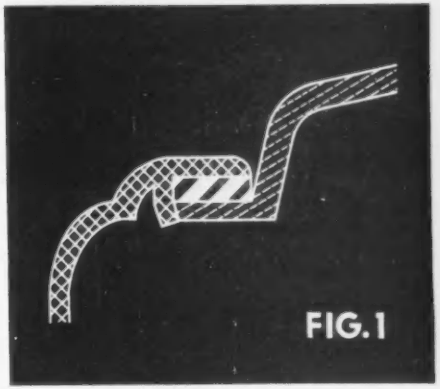
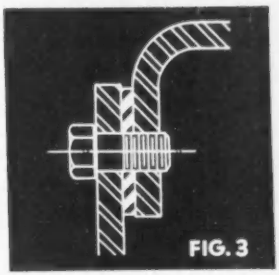
Designing joints for low-cost sealing





An effective seal at least cost is usually the result of designing the joint and its gasket as a unit. In this way, alternate types of flange construction with their appropriate gaskets can be judged against specific application requirements to determine the most economical method for sealing a given joint.

For many applications, stamped or spun metal flanges may offer attractive cost advantages. Such flanges, however, often impose severe demands on ordinary gasket materials because of their irregular surfaces, lack of rigidity, and smaller areas of contact.

In such cases, an Armstrong's Cork-and-Rubber Composition usually will provide an effective, low-cost seal. In these materials, compressible cork particles are combined with synthetic rubber to provide soft, impervious compositions that will seal irregular surfaces with relatively low bolt pressures.

In figure 1, for example, a molded plastic lens and crimped die-cast flange are sealed against weather. The soft cork-and-rubber composition seals tightly by conforming to surface irregularities in both the flange and the lens.

To seal the rolled edge tank and pressed steel cover shown in figure 2, a somewhat firmer cork-and-rubber composition was chosen. Truly compressible cork-and-rubber seats firmly on the rolled edge to provide a tight seal. The exposed cork particles provide added friction, so the gasket won't tend to slip out of place.

Cork-and-rubber, likewise, provides an effective low-cost seal in the assembly shown in figure 3. The gasket not only seals tightly between the flanges, but it also fits snugly around the bolts to prevent seepage.

Gaskets made from an Armstrong's Cork-and-Rubber Composition may provide similar savings for you. Your Armstrong representative will be glad to give you details.

Send for this Gasket Handbook

You'll find useful application and specification data in the new, enlarged 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date data on synthetic rubber, cork-and-synthetic-rubber, cork composition, and fiber sheet sealing materials.

This booklet includes ten technical discussions of the factors influencing modern gasket and joint design. It also suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries. Also included are typical applications and current government specifications.

For your free copy, fill in coupon at right and mail today.

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Please send me at once a copy of the new 24-page booklet, "Armstrong's Gasket and Sealing Materials."

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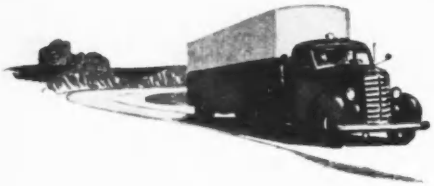
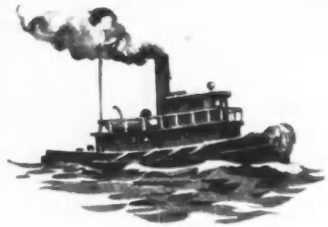


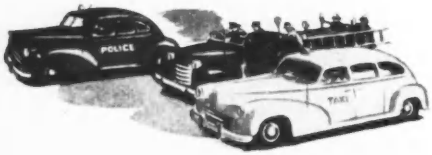
Mallory Vibrators Are Relied Upon For Complete Dependability



Whatever your vibrator application, the odds are that a standard Mallory Vibrator already is performing a similar job. The illustrations on this page are only a few of many examples where Mallory Vibrators are giving dependable service.

Mallory engineering skill, long experience, and complete adherence to quality ideals mean that Mallory Vibrators will give you longer life and less trouble.

More Mallory Vibrators are used in original equipment than all other makes combined. Why take a chance on anything less than this standard of excellence?



Send complete technical details of your problem. Mallory will supply the answer.

Vibrators and Vibrapack* Power Supplies

P. R. MALLORY & CO. Inc.

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Capacitors	Rectifiers
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She knows (as you do) Light weight made them portable. Strength made them practical. Economy of manufacture put a price tag on these sewing machines that thousands of women couldn't resist.

That's how Alcoa Aluminum Die Castings rang the bell for this sales-wise manufacturer. Their light weight, strength and exceptional economy can do the same for your products, too. Start planning now with the book "Designing for Alcoa Die Castings". Ask your nearby Alcoa Sales Office or write ALUMINUM COMPANY OF AMERICA, 611-J Gulf Building, Pittsburgh 19, Penna.

She doesn't know (but you do) With the ability of the Alcoa organization come important advantages of Alcoa Die Castings themselves. They do not "creep" nor "grow". They are excellent conductors of heat and electricity. Add these advantages to a bonus of light weight and a competitive price structure.

ALCOA ALUMINUM Die Castings merit your *FIRST* consideration

ALCOA FIRST IN **ALUMINUM**

ALCOA ALUMINUM

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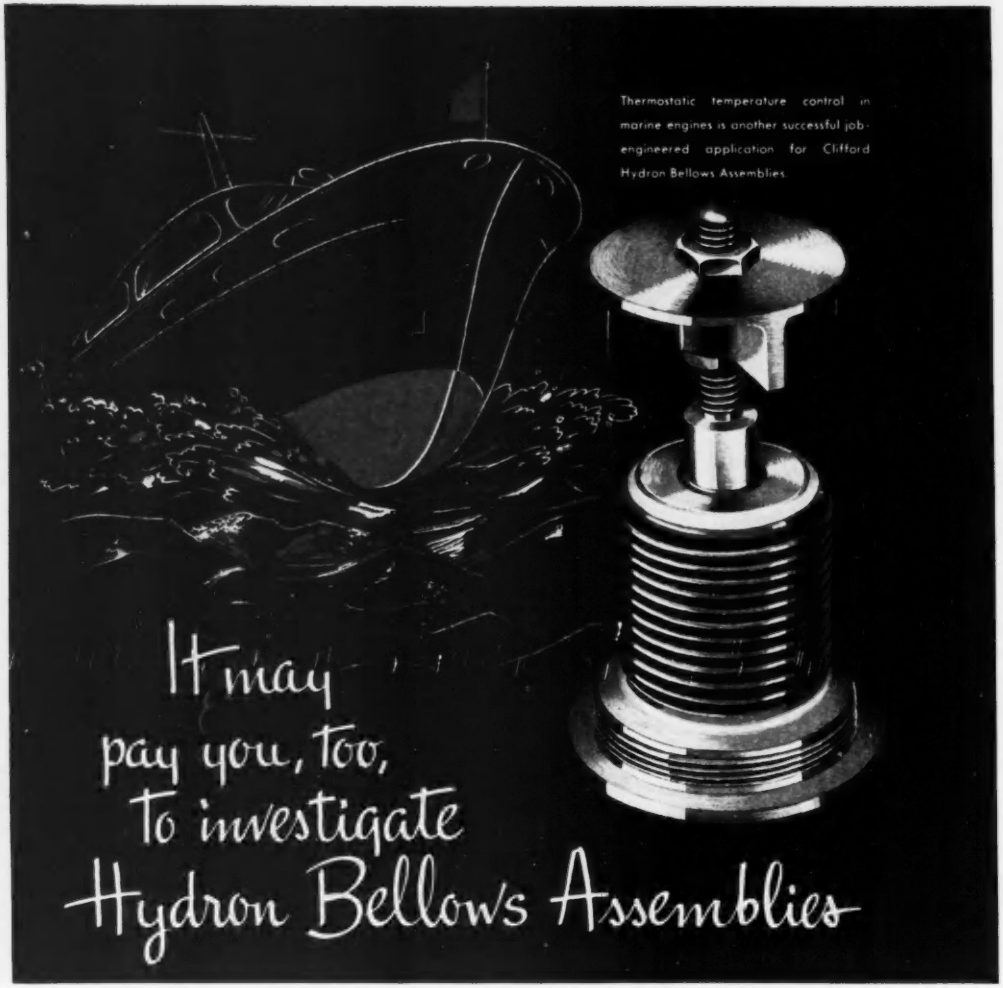
ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS


Thermostatic temperature control in marine engines is another successful job-engineered application for Clifford Hydron Bellows Assemblies
It may pay you, too, to investigate Hydron Bellows Assemblies

More and more design engineers are specifying Hydron Bellows Assemblies, not only for temperature and pressure control, but also for sealing rotating shafts against leakage in compressors, gear boxes, torque converters, refrigerators, automotive fluid drives and other equipment. Each of these assemblies is engineered to fit individual specifications. Before your designs are too far advanced, let our engineering department make a confidential analysis of your sketches and submit recommendations. No cost or obligation, of course. CLIFFORD MANUFACTURING COMPANY, 122 GROVE ST., WALTHAM 54, MASS. *Division of Standard-Thomson Corporation.* Offices in New York, Detroit, Chicago, Los Angeles.

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ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

Cut Production Costs... Improve Your Product

MEMO

TO: Industry's Production Executives

FROM: Geuder, Paeschke and Frey Co.

It's possible for you to end many production headaches by using the overall metal processing facilities offered by G. P. & F.'s Complete Fabricating and Finishing Service. This includes:

1. Engineering—Designing
2. Stamping—Drawing—Forming
3. All Types of Welding
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Add to your manufacturing profits by obtaining from a single source completed units—made to your specifications —finished—ready to assemble—or completely assembled.

Before expanding your production lines by adding costly equipment, investigate Geuder, Paeschke & Frey's capacity to design, fabricate and finish sheet metal products and product components for you.

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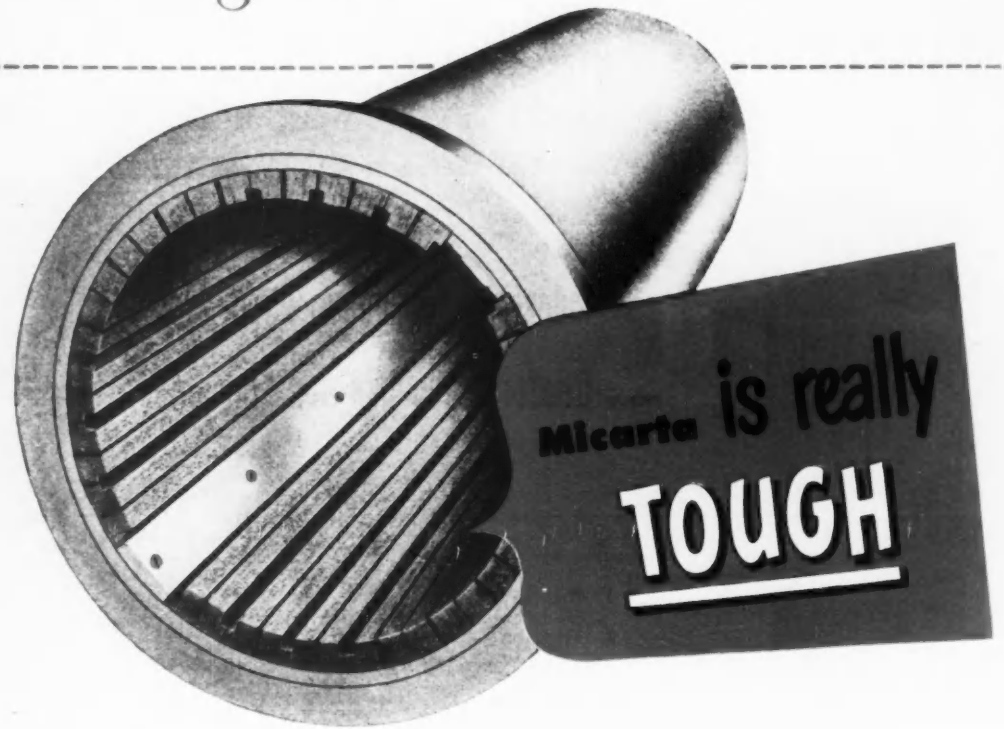
Westinghouse



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Micarta offers you a way to beat wet operating conditions.

Typical of the way it performs in damp locations are stern-tube bearings for the marine industry. This is a job calling for a heavy-duty, long-wearing material for grueling underwater service in heavy seas. Here, it multiplies bearing life as much as 400%, wears slowly and evenly, resists shock and stress.

This may suggest ways that Micarta can help your product or production problems. You may also benefit by Micarta's light weight, stability at extremes of temperature, flexural strength, resilience and electrical insulating properties.

You can order Micarta in standard sheets and structural shapes, in sheets for forming, or completely fabricated, formed or molded, to your specifications by Westinghouse. Ask your nearby Westinghouse office for Micarta Data Book B-3184-C, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna.

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Wiring Components FOR PRODUCT DESIGN

Now—No Fraying No Kinking

It's PREEN-X

THE NEW IDEA IN HEATER CORDS

Here's a really new idea in a heater cord set—General Electric Preen-X heater cord equipped with the handsome General Electric "400" plug.

Preen-X heater cords come with ends stripped and twisted ready for fast installation. They help speed-up assembly, provide an added sales feature. Preen-X has no braid to fray or unravel. Its tough, flexible-insulation jacket—*by actual tests*—takes ten times the abrasion of ordinary heater cords. Preen-X resists water and oil—looks smart on any up-to-the-minute appliance.

The bright, colorful "400" plug makes an attractive-looking companion piece to the new Preen-X heater cord. Made of tough plastic in attractive colors, this gleaming plug adds sales appeal to appliances—attracts customer attention. Strong prongs and sturdy construction make the "400" plug a long-life item.

Before you specify another foot of heater cord, it will pay you to look at Preen-X. For a free sample and all of the facts on this new fray-resistant, non-kinking heater cord, check "A" in the coupon below.

Formex® Magnet Wires

Deltabeston® Magnet Wires

2 great magnet wires from a single source

TO FILL EVERY WINDING NEED

To provide a full range of sizes, shapes, and insulations . . . for a wide variety of applications . . . General Electric offers two great names in magnet wires—Formex, for temperatures to 105 C; and Deltabeston, for temperatures to 125 C.

Formex is the tough, workable magnet wire, insulated with synthetic resin, that is famous for speedy winding and extremely long operating life. Chemical-resistant, heat-shock resistant, abrasion-resistant, space-saving Formex magnet wires are available in all common sizes and shapes.

Deltabeston magnet wires, insulated with glass or with asbestos, are the high-heat magnet wires that permit operation at temperatures higher than those allowable for ordinary cotton- or enamel-insulated wires. Deltabeston magnet wires are available in all the usual sizes and shapes.

For samples of these two famous General Electric magnet wires and the latest booklet containing complete detailed information just check "B" in the coupon below.

LOST!

One repeat sale

"Just look at this frayed cord. Why don't 'they' put durable cords on appliances?"

Why run the risk of being the "they" she's talking about?

Long-lived, good-looking General Electric Flamenol® rip cords are made to bring products through tough situations and to keep them performing well. They're the cords designed to give your product a selling edge over competition before the sale. And they keep your product sold after the sale—that critical period when customers really learn about product quality in terms of day-in, day-out use.

Flamenol cords resist acids, alkalies, water, and oils. Your customers will like the smooth, extra-flexible Flamenol jacket that is easily cleaned with a quick wipe—always looks neat. You'll like the way they can be stripped, quickly and cleanly, for fast installation.

Why not see what these long-wearing cords can do to help your sales and manufacturing picture? To get the facts just check "C" in the coupon.

General Electric Company (Section LS-967)
Construction Materials Department
Bridgeport 2, Connecticut

Please send me, free, the following:

A ☐ **Sample and data on Preen-X—the newest in heater cords.**

B ☐ **Information and samples of Formex and Deltabeston Magnet Wires**

C ☐ **Data on General Electric Flamenol rip cords**

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GENERAL ELECTRIC

ALL IRON CASTINGS ON BLISS PRESSES ARE MEEHANITE METAL

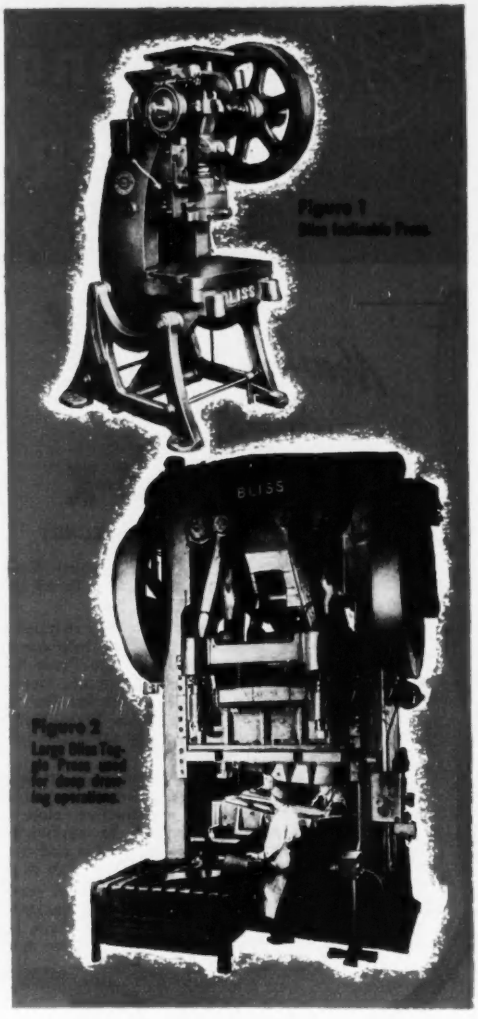

Figure 1
Bliss Inclinable Press.

Figure 2
Large Bliss Toggle Press used for deep drawing operations.

E. W. BLISS COMPANY, Detroit, Michigan, prominent manufacturers of a line of mechanical and hydraulic presses as well as other machinery, operate two Meehanite foundries. The hundreds of tons of Meehanite castings produced in these plants are used as structural components for their products.

In their line of presses ranging from a small Inclinable Press, Figure 1, to the Giant deep-drawing Toggle Press, Figure 2, Meehanite castings are used for such important parts as frames, flywheels, brake and clutch housings, connections, slides, etc. Presses of these types must be rugged and must perform precision work. Their design must incorporate maximum rigidity for die life with a proper safety factor below the elastic limit of the structural material in order to be sure of eliminating permanent set. Meehanite castings provide these qualities accompanied by resistance to fatigue and impact, high compressive and tensile strength and excellent vibration absorption qualities.

For further facts about the importance of quality castings as units of construction write for the bulletin "The Vital Component—Good Castings." For a copy write to any of the foundries listed.

MEEHANITE FOUNDRIES

American Brake Shoe Co. — Mahwah, New Jersey	General Foundry & Manufacturing Co. — Flint, Michigan	Ross-Meehan Foundries — Chattanooga, Tennessee
The American Laundry Machinery Co. — Rochester, New York	Greenlee Foundry Co. — Chicago, Illinois	Shenango-Penn Mold Co. — Dover, Ohio
Atlas Foundry Co. — Detroit, Michigan	The Hamilton Foundry & Machine Co. — Hamilton, Ohio	South Industries, Inc. — Indianapolis, Ind.
Banner Iron Works — St. Louis, Missouri	The Henry Perkins Co. — Bridgewater, Massachusetts	Standard Foundry Co. — Worcester, Massachusetts
Barnett Foundry & Machine Co. — Irvington, New Jersey	Johnstown Foundries, Inc. — Grove City, Pennsylvania	The Stearns-Roger Manufacturing Co. — Denver, Colorado
H. W. Butterworth & Sons Co. — Bethayres, Pennsylvania	Kanawha Manufacturing Co. — Charleston, West Virginia	Traylor Engineering & Mfg. Co. — Allentown, Pennsylvania
Continental Gin Co. — Birmingham, Alabama	Koehring Co. — Milwaukee, Wisconsin	U. S. Challenge Co. — Centerville, Iowa
The Cooper-Bessemer Corp. — Mt. Vernon, Ohio and Grove City, Pa.	Lincoln Foundry Corp. — Los Angeles, California	Valley Iron Works, Inc. — St. Paul, Minnesota
Crawford & Doherty Foundry Co. — Portland, Oregon	E. Long Ltd. — Orillia, Ontario	Vulcan Foundry Co. — Oakland, California
Farrel-Birmingham Co., Inc. — Ansonia, Connecticut	Otis-Fensom Elevator Co., Ltd. — Hamilton, Ontario	Warren Foundry & Pipe Corporation — Phillipsburg, New Jersey
Florence Pipe Foundry & Machine Co. — Florence, New Jersey	Pohlman Foundry Co., Inc. — Buffalo, New York	"This advertisement sponsored by foundries listed above."
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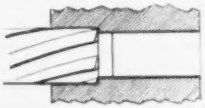
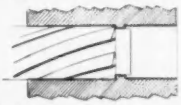
Meehanite® NEW ROCHELLE, N. Y.

THE OLD WAY

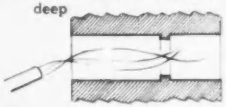
1. Drill 25.5 m.m. (1.004") hole full length



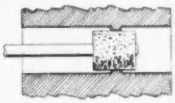
2. Machine bore to 1.761", .9975" deep



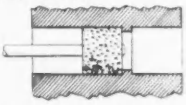
3. Rechuck and machine opposite end of bore to 1.761", 1.9355" deep



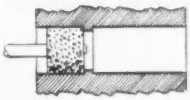
4. Heat treat and quench



5. Grind .00355" off shoulder inside diameter



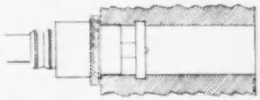
6. Grind .0025" off bore, one end and .0025" off side of shoulder



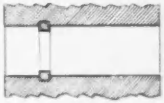
7. Rechuck and grind .0025" off bore, opposite end and .0025" off side of shoulder

RELIANCE WAY

1. *Drill 1.811" (30 M.M.) hole, full length



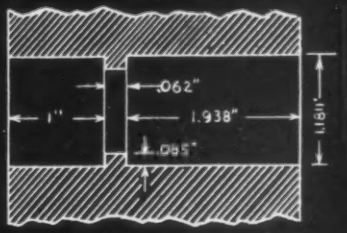
2. Recess groove .074" wide and .040" deep in bore, 1" from end



3. Snap Reliance Ring in groove

* For some applications, seamless tubing may be used, eliminating all drilling.

No heat treating is normally required as ring is already hardened. No danger of warpage. If bore must be hardened, it may be ground in one pass after heat treating.



HOW RELIANCE RINGS

(AND GROOVING TOOL)

Slash the Cost

of internal shoulders

The drawing and comparison chart above show how Reliance Rings and the Reliance Grooving Tool slashed the cost of internal shoulders on a typical application, eliminating four operations — saving time and money.

Reliance Snap Rings are available in carbon, alloy, stainless steel or non-ferrous metal to specified physicals, cross sections and diameters—ends shaped to meet any requirement. Reliance Rings offer opportunities for cost reduction, time saving and product improvement limited only by human ingenuity in finding new uses for them.

Reliance engineers will be pleased to study your prints or parts and lend the benefit of their experience in considering possible application of Reliance Rings to your product. Or, if you prefer, a competent representative will call to discuss the possibilities with you. Write, phone or wire your nearest Reliance Sales Office.

EATON

EATON MANUFACTURING COMPANY

RELIANCE RINGS

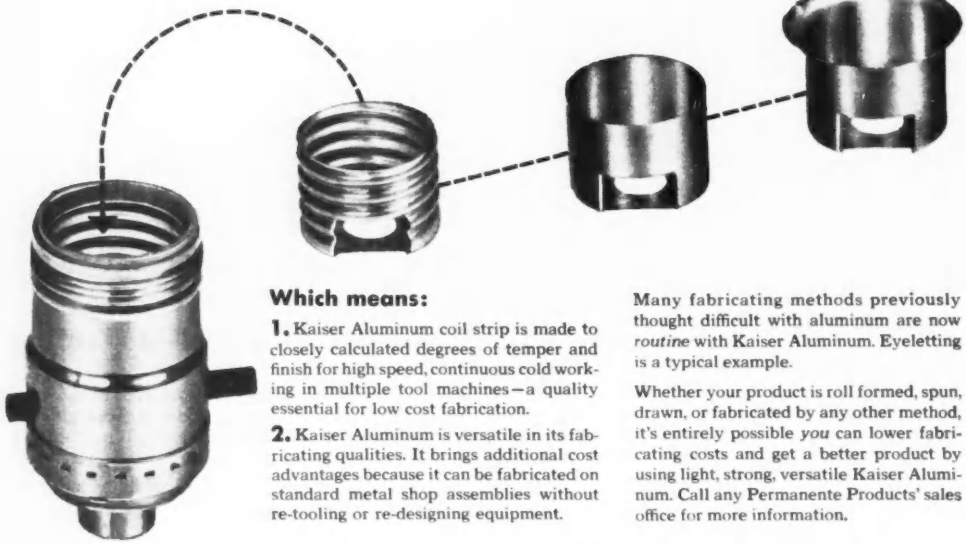
RELIANCE DIVISION, MASSILLON, OHIO

Sales Offices: New York, Cleveland, Detroit, Chicago, St. Louis, San Francisco, Montreal

WATERBURY BRASS GOODS BRANCH of the American Brass Company turns out aluminum screw shells for socket assemblies—approximately 2500 of them an hour. They use an eyelet machine—an automatic multiple plunger power press—to transform a section of Kaiser Aluminum coil strip into a blank—then into a screw shell—in 1½ seconds! Here are the seven steps from blank to shell.

In this eyeletting operation...

Kaiser Aluminum forms readily—rapidly



Which means:

1. Kaiser Aluminum coil strip is made to closely calculated degrees of temper and finish for high speed, continuous cold working in multiple tool machines—a quality essential for low cost fabrication.

2. Kaiser Aluminum is versatile in its fabricating qualities. It brings additional cost advantages because it can be fabricated on standard metal shop assemblies without re-tooling or re-designing equipment.

Many fabricating methods previously thought difficult with aluminum are now *routine* with Kaiser Aluminum. Eyeletting is a typical example.

Whether your product is roll formed, spun, drawn, or fabricated by any other method, it's entirely possible *you* can lower fabricating costs and get a better product by using light, strong, versatile Kaiser Aluminum. Call any Permanente Products' sales office for more information.

Permanente Metals

PRODUCER OF

Kaiser Aluminum

SOLD BY PERMANENTE PRODUCTS COMPANY, KAISER BLDG., OAKLAND 12, CALIFORNIA . . . WITH OFFICES IN:

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60 YEARS OF STAR PERFORMANCE 1948

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IN 17 DEGREES
IN PERFORMANCE
IN QUALITY

KOH-I-NOOR Drawing Pencils are precision instruments of the finest quality, professionally designed and manufactured by the most modern type of machinery. Expert supervision of every step, meets the exacting requirements of all architects, draftsmen, engineers and artists.

Specifications . . . 17 Degrees ✓ Uniform Accurate Grading ✓ Long Wearing ✓ Unsurpassed Breaking Strength ✓ Smooth ✓ Clear, Sharp Lines ✓ Black ✓ Opaque (Perfect Reproduction) ✓ Long Seasoned Cedar ✓ Strong Wood-Lead Adherence ✓ Lustrous Finish ✓

The Time-Tested #1500... 10¢

Again Available...#1600

KOH-I-NOOR POLYCOLOR PENCILS
WITH IMPORTED LEADS
IN 65 COLORS

NEW!
THE
SUPER-DE-LUXE
KOH-I-NOOR #1500-I
DRAWING PENCIL
15¢

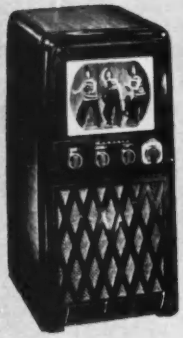
Degree Marking in Brown Panel
Rounded Dipped End
Imported Leads—17 Degrees
Printed Cellophane Wrap
Packed in Metal Boxes

KOH-I-NOOR PENCIL COMPANY, INC.
BLOOMSBURY, NEW JERSEY

It pays to use your custom molder's know-how

Say Admiral officials, who think BIG in production, sales—and plastics

No. 9 in a series on Plastics Skill at Work...



PROJECT
One-piece cabinet for floor model television set

CUSTOMER
Admiral Corporation
Chicago, Illinois

MOLDER
Molded Products Corporation

MATERIAL
High grade phenolic molding compound

WORLD'S LARGEST (35 lb.) compression-molded television cabinets are produced in six minutes. Recently developed low-pressure molding materials open new possibilities in molding larger one-piece units.

LOWER SELLING PRICE results from elimination of many finishing operations necessary with other materials. This big television housing comes from mold ready for assembly, has integral lustrous finish.

To give its dealers a tremendous selling edge with the lowest priced television console ever offered, Admiral Corporation had the courage to order the largest phenolic plastic molding ever made in this country.

Weighing no less than 35 pounds as it comes from the mold, this job has design and production implications for manufacturers in many fields outside of radio-television. The use of phenolic material enabled Admiral to eliminate many expensive hand-finishing operations. As a result its costs were cut, sets turned out faster, and big savings passed on to the retail customer through lower prices. Sales are soaring.

The consulting firm and molder of the new console is Molded Products Corporation, who undertook this difficult assignment after balancing all risks against their own skill with plastics. Long familiar with the qualities of Durez phenolic molding compounds, they chose a phenolic material for dimensional stability, glossy finish, light weight, and low cost... qualities *you may well want for your products.*

When you need the right material for the right job, plan on using Durez. Your Durez field man has wide experience. He will gladly serve you and your molder in planning sessions.

A new hit with plastics users everywhere is the handy "Durez Check-Chart." Write for yours. Durez Plastics & Chemicals, Inc., 159 Walck Rd., N. Tonawanda, N. Y.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB

ELECTRUNITE

Stainless Steel Tubing

DATA and STOCKS...

Representatives located in: Birmingham • Boston • Buffalo • Chicago • Cincinnati • Cleveland • Denver • Detroit • Houston • Indianapolis • Kansas City • Los Angeles • Milwaukee • New York • Philadelphia • Richmond • St. Louis • San Francisco and Seattle.
Distributors located in: Baltimore • Boston • Buffalo • Charlotte, N. C. • Chicago • Cincinnati • Cleveland • Columbus • Hartford • Houston • Kenosha, Wis. • Kansas City • Kingsport, Tenn. • Los Angeles • Oakland • Philadelphia • Pittsburgh • Portland • St. Louis • San Francisco • Seattle • Shreveport • Sumter, S. C. • Toledo • Union, N. J., and Waynesboro, Va.

WHEN AND WHERE YOU NEED THEM!

● Right in your own city—or in one nearby—there's a Steel and Tubes representative ready to give you helpful technical information on stainless steel tubing.

He's the man who can tell you the complete story about ELECTRUNITE Tubing made of Republic ENDURO* Stainless Steel; *why it's always uniform in diameter, wall thickness, concentricity, strength, ductility and workability.* He can advise you, too, on the selection of the proper stainless steel analysis to best meet specific application requirements.

And in the same city—or not far away—is your ELECTRUNITE Distributor who can supply you with ELECTRUNITE Stainless Steel Tubing from warehouse or on mill delivery *in both pipe and tubing sizes.* You'll find him always ready to help you in any way possible.

Get in touch with your Steel and Tubes sales representative and your ELECTRUNITE Distributor. They're good men to know. If you would like their names and addresses, write us.

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
Export Dept.: Chrysler Bldg., New York 17, N.Y.

*Reg. U. S. Pat. Off.

Republic
REPUBLIC STEEL
ELECTRUNITE
STAINLESS STEEL TUBING

SYLPHON

bellows assemblies and devices

● There's one paramount rule at our plants: every bellows assembly and device must be built to do its job to perfection—to *your* satisfaction. Bellows devices that "just get by" are never good enough for us or our customers.

That's why so many engineers come to us whenever they have design problems where bellows assemblies and devices can be used—in aiding control of temperatures or pressures, motion transmission, shaft seals and scores of other applications.

Bellows devices are built *on order* to your specifications. And to assure completely satisfactory performance, our engineers gladly help you in their design and development—give you personal "follow through" service. Wide range of metals, and sizes from $\frac{15}{32}$" to 12" O.D. Write Department RP for complete information.

TEMPERATURE CONTROLS

FULTON SYLPHON DIVISION
Knoxville 4, Tenn.

Robertshaw-Fulton CONTROL COMPANY

BELLOWS ASSEMBLIES • BELLOWS DEVICES

BRIDGEPORT THERMOSTAT DIVISION
Bridgeport 1, Conn.

Brown of Philadelphia makes unexpected triple play

1 Abolishes costly rejects

2 Eliminates unit air testing

3 Saves 16% on machining

Base for Throttling and Reset Type Air-Actuated Control Unit

Non-Bleed, Pilot Relay Valve Body. Illustrations are approximately three-quarters actual size.

When Anaconda Die Pressed Brass Forgings replaced sand castings for these two all-important parts of Brown Air Operated Controllers, the play was for a single out – elimination of "leakers" – which, on occasion, ran as high as 60% on underwater air tests and showed up only after complete machining. Naturally, when *wrought* metal replaced the sand castings, "leakers" were out by a mile – so completely out that costly unit air testing was found to be unnecessary.

That was more than nine years ago, and of the tens of thousands of forgings used in the meantime, nary a one has been thrown out for porosity.

Savings? Plenty – in time and temper – and in cold cash, too. For instance: 16% on combined tooling and machining costs for the base forging alone . . . and that is only one of the many Anaconda Die Pressed Brass Forgings now being used in Brown Instruments.

There are a lot of things about Anaconda Die Pressed Forgings you'll want to know. Publication B-9 goes into detail, telling where, why, how and when. Write for a copy today. Address, The American Brass Company, General Offices: Waterbury 88, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA

Anaconda
DIE PRESSED FORGINGS

BROWN

This is the Brown AIR-O-LINE Recording Flow Controller, manufactured by the Minneapolis-Honeywell Regulator Co., Brown Instruments Division, Philadelphia. Brown Air Operated Instruments are used the world over for automatically controlling temperature, pressure, flow, liquid level and humidity in industrial processes.

Don't just pick any wire

Let us make it to fit the job exactly

Here in the mills of The American Brass Company, more than 100 different copper alloys are processed into wire in an almost unlimited variety of sizes and shapes, tempers and finishes. The result is that each wire is, in effect, tailor-made . . . especially adapted to particular problems of tooling, rate of production, and desired properties of the finished product. And there's a big difference – both in quality and unit cost – when the wire is exactly suited to the job!

The column at the right very likely holds the combination to that "one best wire". Our Technical Department will help you find it – and it may be easier than you think. Your inquiry entails no obligation whatever.

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA
from mine to consumer

Anaconda
COPPER and COPPER ALLOY
Wire

TYPICAL TYPES OF WIRE

Pin Wire	Hook & Eye Wire	Nail Wire
Screw Wire	Cotter Pin Wire	Rivet Wire
Chain Wire	Brake Lining Wire	Tie Wire
Slide Fastener Wire	Fourdrinier Wire	Welding Wire
Jewelry Wire	Trolley Wire	Brazing Wire

MATERIALS

Copper	Brass	*Hitenso Cadmium Bronze
Chromium Copper	Zinc	*Calsun Bronze
Deoxidized Copper	Phosphor Bronze	Ambraloy
Silver Bearing Copper	Nickel Silver	Special Copper Alloys
Gilding	Cupro Nickel	*T.M. Reg. U.S. Pat. Off.
Commercial Bronze	*Everdur	

SIZES AND SHAPES .002" TO .750"

(Extreme limitations—varying according to alloy and shape)

Round	Half-oval	Square
Half-round	Flat	Hexagonal
Oval	Keystone	Octagonal
	Irregular Shapes on Order	

FINISHES AND TEMPERS

Cadmium Plated	Bare	Oxidized
Bright Annealed	Tinned	

From Soft Annealed through Spring Tempers; put up on Spools, Reels, Coils or cut to Straight Lengths.

SUITABLE FOR THESE FABRICATING OPERATIONS

Redrawing	Riveting	Braiding
Cold Heading	Machining	Spinning
Hot Heading	Flat rolling	Weaving
Extruding	Edgewise winding	

To cut the cost of cylindrical parts . . .

here's the place to start

LOOKING for new ways to reduce costs? You can simplify manufacture and save material by using Timken® seamless tubing instead of bar stock for your hollow or ring-shaped parts. With Timken seamless tubing, you start with the hole already there. Finish boring is often your first production step. There's less stock to machine—less scrap loss. Elimination of drills on automatic machines often leaves space for other tools, sometimes almost doubling output.

Because the piercing process by which Timken tubing is made is basically a forging operation, you get added strength for your product as well as lower cost. The tube is thoroughly hot worked during piercing which results in a *uniform grain flow* for great strength, and a *refined grain structure* to bring out the best in the quality of the metal. This fine forged quality of Timken seamless tubing is always uniform. Timken's rigid quality control from melt shop through final inspection assures you of uniformity from tube to tube and heat to heat—and uniform response to your machining and heat treating operations.

TIMKEN TUBE ENGINEERING SERVICE OFFERS *EXTRA* SAVINGS!

To get the most economical size tube for your job, guaranteed to clean up, use our Tube Engineering Service. With the tubing they specify, you waste no time or material machining away excessive stock. Yet you're sure you have *enough* metal to fill out your dimensions. Write today for an analysis of your requirements, without obligation. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

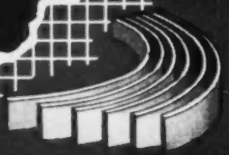
50th birthday of the company whose products you know by the trade-mark: TIMKEN

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.

Reynolds weaves wire cloth for....

GRADING

Shaker Screens grade Cereals, Seeds, Resins, Abrasives and Powders

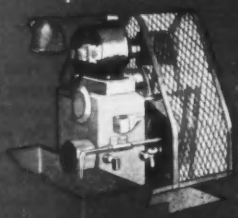


REINFORCING

Wire Cloth—The perfect reinforcing agent for all Compounds, Plastics, Rubber and Building Materials

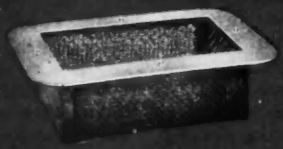
FILTERING

Air Filters and Cleaners—Fluid Filters and Cleaners rely on Reynolds Wire Cloth



GUARDING

Wire Cloth protects Machines from careless hands, and careless hands from machines



STRAINING

Impurities in Engine Lubricants can wear out Moving Parts—Wire Cloth is the ideal strainer

SIFTING

Flour Sifters—Foundry Riddles and all Industrial Sifting

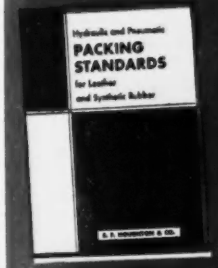
Whatever your wire cloth needs as to metal, weave, mesh, gauge or finish—Reynolds will weave it to your specifications. Consult Reynolds Engineers without cost or obligation.

REYNOLDS WIRE CO.

DIXON, ILLINOIS

Reynolds Industrial WIRE CLOTH

. . . with packing standards



In the movement sponsored by the Joint Industry Conference to set up packing standards, reduce number of sizes and promote interchangeability, Houghton was first to prepare and distribute such simplified standards.

The booklet shown here contains tables of sizes and dash numbers for convenience in ordering. The packing industry generally and the large users have accepted these standards.

AT YOUR SERVICE

That's one valuable aid to industry from this pioneer in hydraulics. Another is the service to designers . . .

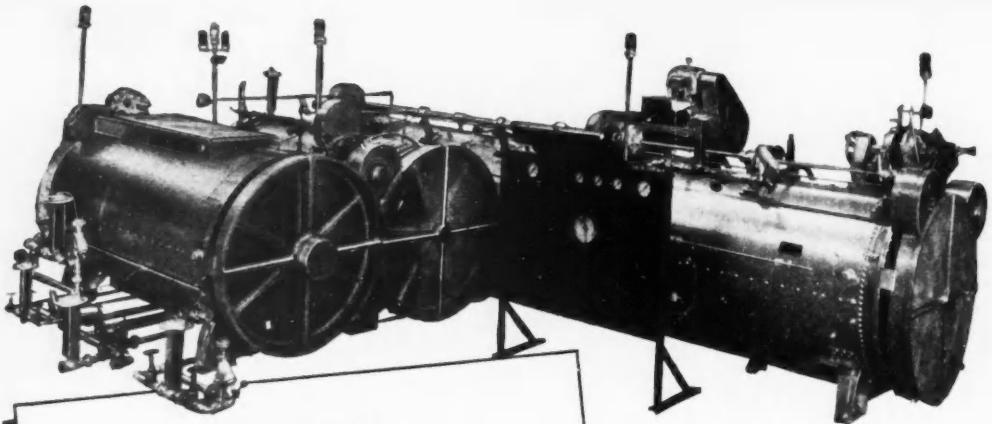
. . . with standard packings

These include leather and synthetic rubber styles —"V", "U", Cup, "O" rings and leather back-up washers.

Let Houghton make a specific recommendation on your next design and if there is trouble on a hydraulic installation due to imperfect sealing, let the Houghton engineer examine the packing set-up. A letter to E. F. Houghton & Co., 303 W. Lehigh Ave., Phila. 33, Pa., will bring results.

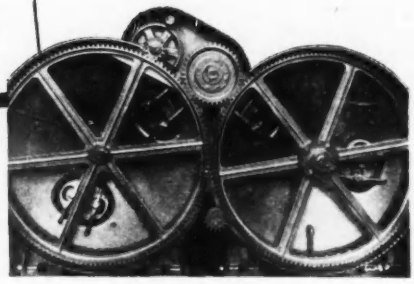
For "know-how" know Houghton

(HOW / TON)



Pressure cooker and cooler built by Anderson-Barngrover Division of Food Machinery and Chemical Corporation, San Jose, California.

BUILT FOR *Pressure Cooking* WITH HEAD-SHAPES 3/4" THICK



Lukens Flared, Dished and Flued Head-Shapes were used for the cooker and cooler ends.

Its 3/4-inch ends dished inward and steel plate construction used throughout, this cooker is really built for high internal pressures. It is safe and dependable.

The use of Lukens Head-Shapes, of a special design, for these cookers and coolers, simplifies their fabrication. There are no forming operations required at the manufacturer's plant: these head-shapes are already dished, flared and flued. Lukens flattens the flange to close tolerances, so little metal has to be machined off.

Many other manufacturers have similarly found that it pays to employ Lukens Head-Shapes either of standard or special design. With the large number of standard styles and sizes available, designs are easily suited to their use. You pay less for standard shapes and the hundreds of dies on hand at Lukens speed up their delivery.

Whether you're building tanks, pressure vessels or other products, you should have Catalog No. 1, listing 3,989 standard Lukens Head-Shapes. For a copy, write Lukens Steel Company, 405 Lukens Bldg., Coatesville, Pa.

LUKENS HEADS

FOUR INCHES TO OVER TWENTY FEET IN DIAMETER

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by BRIDGEPORT BRASS COMPANY "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Screw Machine Products . . .

For Reducing Costs and Product Improvement

Craftsmanship in brass can hardly be better illustrated than by the typical screw machine samples, shown above. These were kindly submitted by the Ansonia Manufacturing Co.

We are all familiar with most of these parts—faucet handles and bonnets; caps of various shapes; knobs, couplings, spray nozzles, etc., which, of course, hardly show the variety and versatility of screw machine products.

Many Brass Alloys Available

Ledrite 6, high speed free-turning brass rod, stocked in our mills and in our warehouses, is ideal for turning, machine threading and broaching. Ledrite 6 (machinability rating 100%), contains about 61% copper, 3.4% lead and balance zinc and satisfies about 90% of screw machine needs.

Items requiring knurling or roll threading may find the standard temper of Ledrite 6 too hard and may require a softer temper.

Some operators prefer Ledrite 2 medium leaded (1.8% lead) for knurling and roll threading because its lower lead content makes it somewhat more ductile.

For a rich bronze color to match cast bronze, use Leaded Commercial Bronze 89, copper 89%, lead 1.75%, zinc remainder (machinability rating 80%.)

For corrosion resistance to sea water, Naval Brass 24 (machinability rating 30%) is often used. Medium leaded Naval Brass 28, containing 0.6% lead (machinability rating 50%) and Leaded Naval Brass 29, containing 1.75% lead (machinability rating 70%) are often used for improved machinability.

Lower Finishing Costs

There has been a definite trend to screw machine products because of possible reductions in finishing costs. The smooth surface of the rod as it leaves the mill and the skill of the screw machine operator to produce a finish which requires the minimum of surface removal for high polish mean less polishing time with correspondingly lower requirements of polishing compounds, buffs, etc. Freedom from porosity and surface defects, and accuracy of shape of screw machine products mean fewer rejections and ultimate lower cost per piece.

Product Improvement

Design and mechanical engineers are not confined to brass alone for items requiring exceptional strength and resistance to corrosion and wear. Silicon bronzes and aluminum bronzes offer many possibilities for improving existing products such as valves, connectors, fittings, electrical and mechanical devices, and controls.

Brass Makes Durable, Safe Poultry Watering Unit

Corrosion resistance, cleanliness and speed of machining makes brass an ideal material for automatic watering devices used either in the henhouse or in the barnyard.

Since a steady flow of clean water is necessary to insure healthy poultry, dependability of a drinking fountain is essential.

The excellent machinability of brass permits rapid turning and threading of the tubing used for the valve body. Free-cutting hexagon Ledrite 6 brass rod is used for the intake nut. Round Ledrite 2 medium-leaded brass rod is used for the knurled and threaded cap which is easily produced in a screw machine at high speeds.

Little Giant Drinking Fountain with portable stand. Courtesy Miller Manufacturing Co., St. Paul, Minn.

BRASS · BRONZE · COPPER · DURONZE — STRIP · ROD · WIRE · TUBING

MILLS IN
BRIDGEPORT, CONNECTICUT
INDIANAPOLIS, INDIANA

In Canada:
Noranda Copper and Brass Limited, Montreal

BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONNECTICUT
Established 1865
"Bridgeport" *District Offices and Warehouses in Principal Cities*

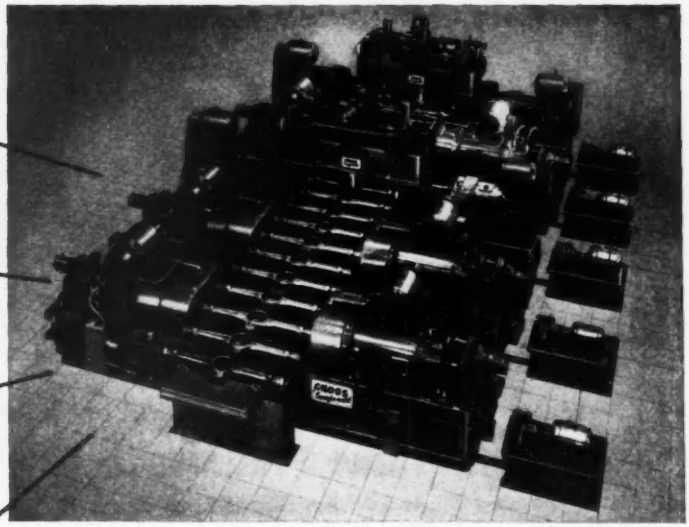
CROSS TRANSFER-MATIC

150 AXLE HOUSINGS PER HOUR WITH 1 OPERATOR

LOWER CAPITAL INVESTMENT

EXCEPTIONAL FLEXIBILITY

SIMPLIFIED MAINTENANCE



Another cost-cutting application of VICKERS HYDRAULICS

The Cross Transfer-matic illustrated here uses Vickers Hydraulic Controls in making substantial reductions in the cost of machining axle housings.

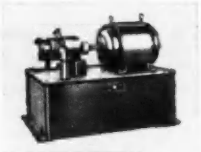
A hydraulic transfer mechanism automatically advances the housings (two at a time) from one machine to another. Hydraulic circuits of the individual machines provide for correct progressive positioning and clamping together with the traversing and feeding of the tool slides. Interlocks assure accurate positioning and secure clamping before cutting operations begin . . . also clearance of all tools before transfer to next station.

Exceptional flexibility is provided in that machines can be added, removed or shifted. Transfer mechanism is independent and moves work only from machine to machine. Locating and clamping are done by work holding fixtures integral with each machine.

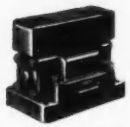
Indicative of the many advantages of Vickers Hydraulics are gasket mounted Vickers Control Valves that simplify installation, save space and make adjustment easier. Vickers Power Units are compact "packages" that simplify hydraulic system design and reduce costs.

Vickers Hydraulics are particularly adapted to provide the complex motions and operations needed in highly automatic machines. Get in touch with the Vickers Application Engineering Office nearest you for information on how Vickers Hydraulics can improve your machinery.

Representative Vickers Hydraulic Pumps and Controls Used on Cross Transfer-matic



Power Unit, Bulletin 46-43a



4-Way Valve, Pilot Operated, Solenoid Controlled, Bulletin 48-27

Flow Control Valve, Bulletin 45-35

Sequence Valve

Check Valve

Pressure Reducing Valve

E 3989

VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

1454 OAKMAN BLVD. • DETROIT 32, MICHIGAN

Application Engineering Offices:

ATLANTA • CHICAGO • CINCINNATI • CLEVELAND • DETROIT • LOS ANGELES • NEWARK • PHILADELPHIA • PITTSBURGH • ROCHESTER ROCKFORD • ST. LOUIS • SEATTLE • TULSA • WASHINGTON • WORCESTER

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

YOU MAY BE JUST 25 MINUTES FROM A FASTENING IDEA WORTH *Thousands of Dollars*

YES, hundreds of fastening ideas that can lead to outstanding savings in assembly costs are contained in the Tinnerman Handbook of Fastenings. It has been created especially for designers, engineers, production and management executives. Takes only 25 minutes to review . . . 25 minutes you may find very worthwhile! *Here's a partial list of contents:*

Page after page of parts drawings and detailed photographs of actual applications classified by type . . . significant case histories on SPEED NUT savings . . . and details on the Tinnerman Fastening Analysis Service.

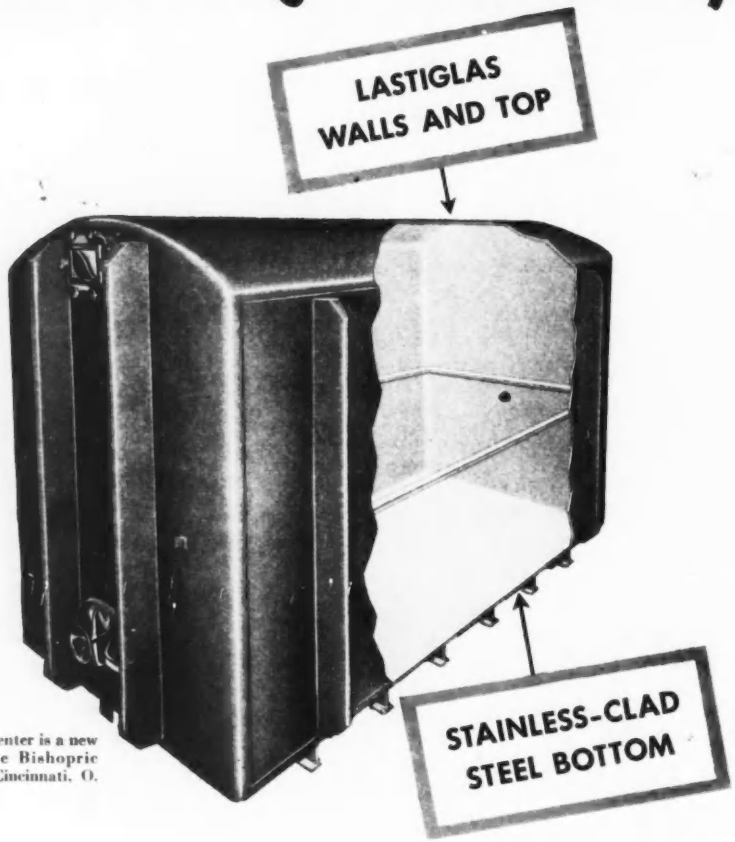
It contains all the data about the amazing SPEED NUT brand of fasteners that are helping a top-ranking car manufacturer save an estimated 3 million dollars this year . . . that cut assembly time 30% for another company . . . that saved $50,000 in equipment investment for still another.

If you're interested in seeing this guidebook of fastenings, call your Tinnerman representative—listed in major city phone directories—or write: TINNERMAN PRODUCTS, INC., 2040 Fulton Rd., Cleveland 13, O.

In Canada: Dominion Fasteners Limited, Hamilton · *In England:* Simmonds Aerocessories, Ltd., Treforest · *In France:* Aerocessoires Simmonds, S. A. Paris

INDEX
The Handbook of Fastening is designed for convenient desk-top reviewing. Complete Index is for quick reference to specific applications for your product.
TINNERMAN Speed Nuts*
*Trade Mark Reg. U. S. Pat. Off.
FASTEST THING IN FASTENINGS

TEAMED UP for greater economy-



This closed fermenter is a new product of The Bishopric Products Co., Cincinnati, O.

No metallic contamination here to harm beer's fine flavor, color and bouquet. The walls of this new fermenter are completely corrosion-resistant; made that way most economically by the combination of materials shown.

The floor of the fermenter, being made of Lukens Stainless-Clad Steel, is protected against wear and shock. It can be walked on, scrubbed and bumped without affecting the protection provided by its stainless steel surface.

In Lukens Clad Steels—Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad—uniform claddings, 10% or 20% of total plate thickness, are permanently bonded to steel backing plates. Thus, equipment has the advantages offered by these *solid* corrosion-resistant metals at the lower cost of *clad* steels.

Your supplier will quote on equipment made of Lukens Clad Steels. Bulletin 449 contains further information on them. For a copy, write Lukens Steel Company, 405 Lukens Bldg., Coatesville, Pennsylvania.

CLAD METAL STEEL

LUKENS
Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

MONSANTO announces . . .

A NEW Molding Powder for the Electrical Industry

RESINOX 10900

mica-filled phenolic molding compound

an outstanding improved formulation with:

Superior Electrical Properties
Excellent Molding Characteristics
Remarkably *Faster* Cure

Physical Properties of Monsanto's New RESINOX 10900

	Average Values
Specific Gravity	1.71
Weight per Cubic Inch	28.0 grams
Flexural Strength	9,000 lbs/square inch
Tensile Strength	6,000 lbs/square inch
Impact Strength	0.35 to 0.40 ft-lbs/inch
Dielectric Strength | S T	400 to 450 vpm
@ 60 cycles S S	350-400 vpm
Power Factor @ 1MC	0.010 to 0.011
Dielectric Constant @ 1MC	4.10 to 4.20
Water Absorption	0.03% by weight
Shrinkage	0.003 to 0.004 inch/inch

Molding Data

Particle Size	Ground to pass U. S. standard 10-mesh screen
Apparent Density	0.75 to 0.85 grams/cc
Bulk Factor	2.01 to 2.28
Pourability	10 to 15 seconds
Preforming Characteristics	Preforms readily in automatic preforming machines
Flow	8 to 18

Values determined under appropriate A.S.T.M. methods.

MONSANTO
CHEMICALS—PLASTICS

SERVING INDUSTRY . . .
WHICH SERVES MANKIND

Monsanto's new Resinox 10900 is an *entirely new* thermosetting powder with a combination of electrical, molding and cure properties unique among "low-loss" molding powders and old-time mica-filled materials.

Unlike past attempts at improving moldability of electrical grade materials, the molding properties of Resinox 10900 have been achieved WITHOUT ANY SACRIFICE OF ELECTRICAL PROPERTIES. (Notice the dielectric strength, dielectric constant, and *low* power factor of Resinox 10900 in the data chart.)

Here is an opportunity for you to decidedly *improve* old products or to *create* entirely new ones heretofore impracticable with available materials. Applications for this new Resinox formulation include control equipment parts, communications parts and television components requiring low electrical loss characteristics at high frequencies, and a wide range of other electrical products.

Best of all, you pay no premium for Resinox 10900. It's available to you at the regular price. Have your molder make a trial run of Resinox 10900 on your job *today*. Or get in touch with us through the coupon below.

Important news to your molder is that Resinox 10900 has a cure rate *two or three times faster* than the best electrical-grade powder now available; it has excellent molding characteristics, smooth flow, and releases from the mold with a rigid set, thus is especially suitable for molding around inserts. Resinox: Reg. U. S. Pat. Off.

MONSANTO CHEMICAL COMPANY
Plastics Division, Dept. PEP 21
Springfield 2, Mass.

I would like further information on Resinox 10900 for _____ (state application)

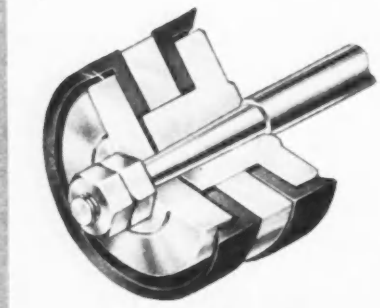
Name _____ Title _____

Firm _____

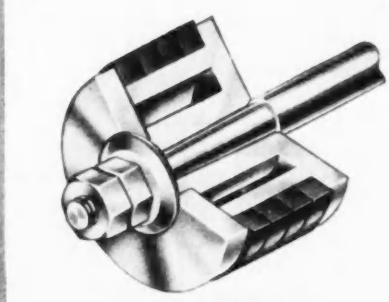
Address _____

City _____ Zone _____ State _____

TWO WAYS TO PACK PISTONS:

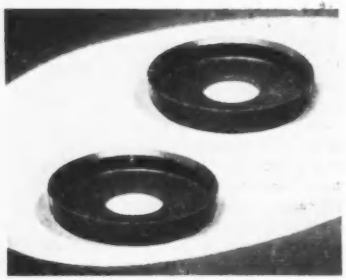


Johns-Manville Moulded Packing Cups



Conventional type piston packing

— Which does the better job?



RECOMMENDED FOR PISTONS IN

Reciprocating Pumps	Compressors
Hydraulic Lifts	Governors
Hydraulic Jacks	Power Shovels
Hydraulic Presses	Grease Guns
Drilling & Boring Machinery	Air Chucks
Air Brake Cylinders	Grinders

Valves (hydraulic or air operated)

BOTH THE PACKINGS shown on these two pistons will do a job. But the piston on the left will operate more efficiently and more economically because it is designed for Johns-Manville Moulded Packing Cups.

Design engineers are expressing a growing preference for these custom-made cups for two reasons: (1) They practically eliminate slippage past the piston. (2) They require less frequent replacement in service.

Johns-Manville Moulded Packing Cups operate like this: Each cup is designed with a flexible lip, which, under discharge pressure, forms a tight seal. On the reverse stroke, the lip relaxes. This action, plus their precise fit, lowers friction and wear on liners and reduces the amount of power required for the stroke.

Wherever Johns-Manville Packing Cups have been used—against water, oil, air, and other liquids and gases—they have proved to be a good investment by increasing efficiency and lowering operating costs. If you design or manufacture any of the equipment listed at left, write for further information about these custom-made cups. Address Johns-Manville, Box 290, New York 16, N. Y.

Johns-Manville *Packings and Gaskets*

YOU CAN BE **SURE**.. IF IT'S

Westinghouse

MOTOR EXCHANGE SERVICE

For Westinghouse
single-phase and three-phase
1 to 20 hp
frame 203 to 326 a-c motors

Another Life-Line First!

The Broadest Exchange Plan!

Since February, 1949, Life-Line motors have offered you the broadest exchange plan in industry. All 1 to 20-hp, single-phase and three-phase a-c motors in frame 203 to 326 are included. No other manufacturer of motors—large or small—provides exchange service that compares in scope to this new Life-Line Motor Exchange Service.

120 Westinghouse exchange points assure you rush motor replacement service anywhere in the United States. Replacement motors, covered by this plan, are in stock, ready to be speeded to you at any time.

And what's more, if a motor fails during warranty period, it may be exchanged *free* for a motor of identical rating. The *exchange price,* beyond warranty, *is not dependent on the time in service . . . one year, five years or ten years.*

This service is one more advantage you get with Life-Line motors. Add this to all-steel construction . . . pre-lubricated bearings . . . an indicated savings of $750 per year per 100 motors . . . and you'll see why Life-Line has gained leading acceptance in the motor industry.

Complete details on the Life-Line Exchange Service—lists of exchange points and motor ratings covered—are given in the new booklet SM-5243. Get your copy today from your nearby Westinghouse representative or write direct to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna. J-21533

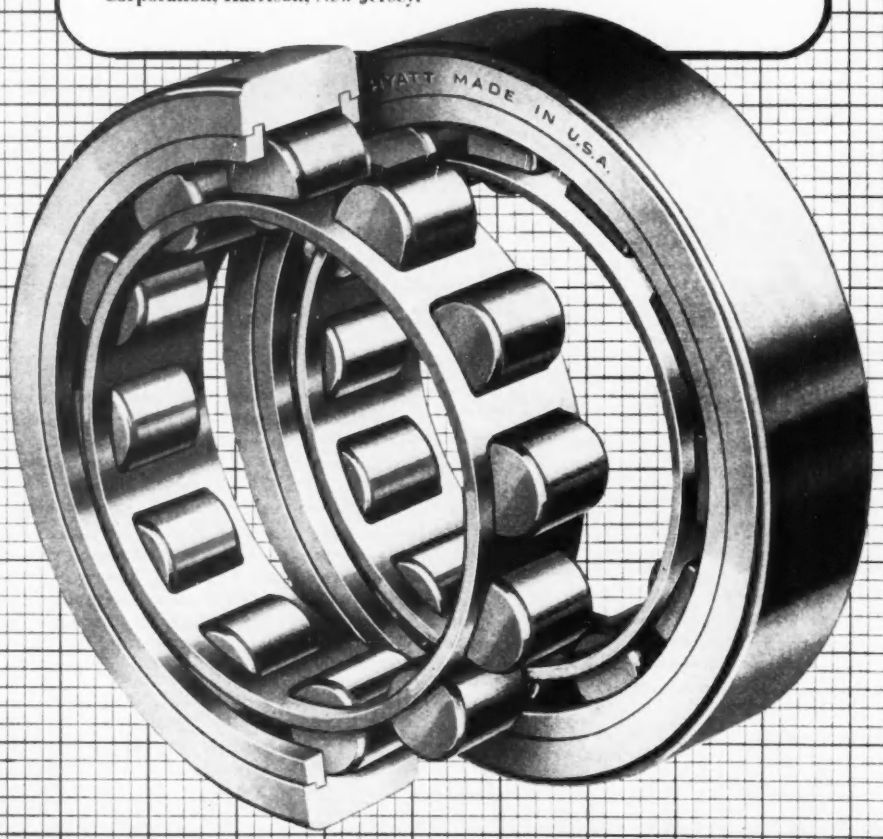
Westinghouse *Life-Line* Motors

Designed in . . . for life

The straight cylindrical construction of Hyatt Roller Bearings permits radial loads carried by the bearing to be evenly distributed over the entire length of the rollers. The larger area of contact between the load carrying elements in straight cylindrical bearings results in greater bearing capacity and longer life with less maintenance.

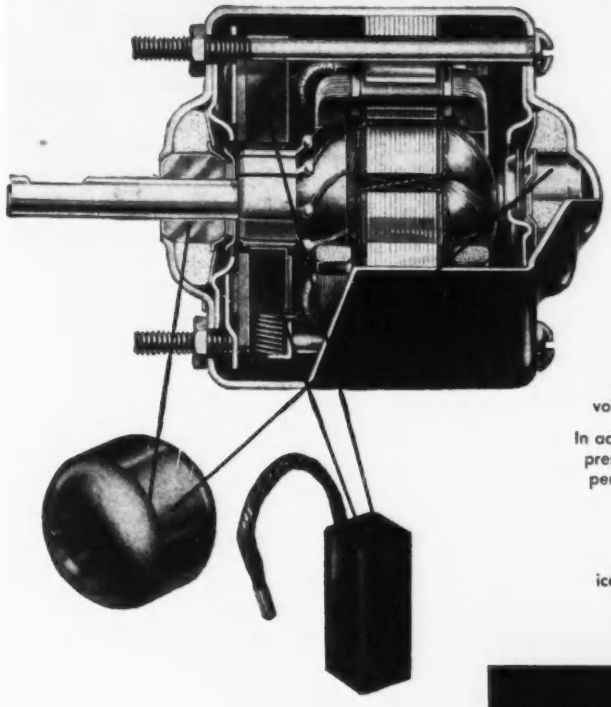
Size for size, Hyatt Hy-Load Roller Bearings offer maximum radial load carrying capacity. They are "designed in" for the life of your equipment.

To get the most out of the equipment you build, sell or buy, be sure that it is equipped with Hyatt Roller Bearings. Let us tell you more about what we can do for you. Write to Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.



HYATT ROLLER BEARINGS

gramix bearings and U.S.G. brushes help insure efficiency of *Redmond* Micromotors

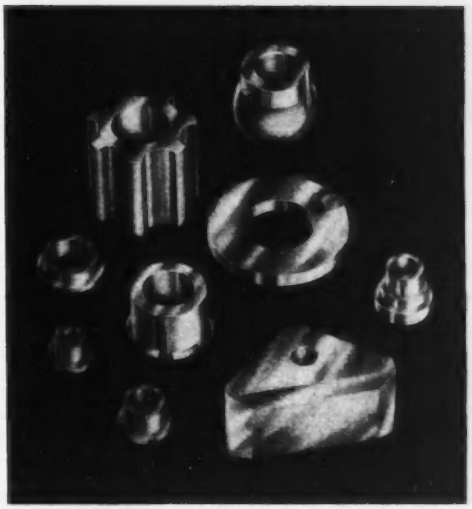


Gramix powder metal bearings and U. S. G. brushes are two important reasons for the outstanding dependability of Redmond Micromotors. U.S.G. copper-graphite brushes have high current carrying capacities and provide positive, noiseless commutator contact. The Gramix bearings reduce shaft play and noise, because they are self-aligning and are selectively fitted to the shaft to retain clearance within .0005". They provide automatic lubrication, with microscopic pores that filter lubricant from the reservoir and distribute it evenly and freely.

In addition, Gramix bearings cost less. They are die-pressed from powdered metal to exact size and with perfect bearing and sliding surfaces, eliminating costly machining. Send us sketches or descriptions of your products, and we will show you where Gramix bearings, washers, gears, and other powder metal parts will improve mechanical performance and save you money. WRITE TODAY FOR NEW GRAMIX CATALOG ***just off the press.***

U.S.G. brushes

We manufacture a complete line of brushes for all types of rotating electrical equipment. Types include carbon-graphite, pure graphite, and metal-graphite with electrical carrying capacity ranging from 30 to 150 amperes per square inch. Our engineers will be glad to assist you in determining which grade and type of USG brush is best suited to your requirements.



gramix bearings
U.S.G. brushes

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

Records prove the unusual ability of Whitney Roller Chains to withstand shock loads without breakage. A case in point is the following application:—

The head rig drive to the large nine foot Sumner Band Mill at Universal Box Company Ltd. incorporates 3 strand, 1½" pitch, Triplex Whitney Roller Chains for positive transmission of power from the 300 HP synchronous motor. Despite surges in power up to 650 HP (or 350 HP overloads) during the cut run, Whitney Chains withstand these tremendous overloads and are performing day in and day out without failure.

In addition to absorbing shock loads, Whitney Chains transmit full rated horsepower without slippage or friction loss. They deliver constant power smoothly and efficiently . . . stand up under the toughest of operating conditions. Write for information.

CHAIN DRIVE IS BETTER

- Positive grip
- Transmits full horsepower
- Simplifies transmission designs
- Low maintenance
- Ease of installation
- Long operating life
- Constant uniform speeds
- High resistance to shock loads
- High load carrying capacity

WHITNEY CHAIN & MFG. CO.

Division of Whitney-Hanson Industries Inc.

204 Hamilton Street, Hartford 2, Connecticut

HOW TO BETTER CONTROL AN AUTOMATIC LATHE

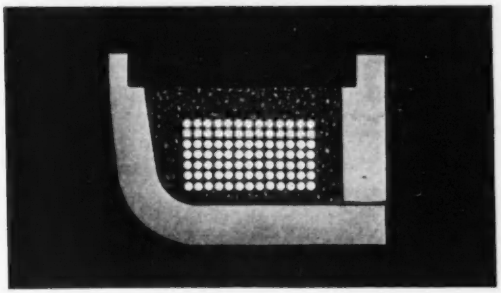
...give it a Brake*!

***And the Brake to give it is a WARNER ELECTRIC INDUSTRIAL CLUTCH-BRAKE**

SUNDSTRAND MACHINE TOOL CO. USES 3 Warner Electric Industrial "ICB" units on their Model 16 Automatic — Two on main spindle drive and one on rapid traverse. Here's what they say about them — "Easy to Control." Main drive motor is standard 75 hp. and constantly running. Warner ICB* units give positive instant control for starting and stopping of spindle. That means short cycle time . . . no special electrical equipment . . . no sudden power surges on factory lines.

HERE'S WARNER ICB UNITS installed on drive shaft of Sundstrand Model 16 Automatic. Sundstrand says these units are "compact, easy to install" . . . and most important "need no adjustment." ICB Units are available in wide range of sizes to meet requirements. Can also be fitted to standard NEMA motor shafts.

ARMATURE SECTION: One of only two parts for either Clutch or Brake units. Consists of magnetic segments welded to steel backplate (see cut). Especially designed for high heat dissipation. Heat has no effect on unit efficiency because segment expansion is always linear . . . thus keeping full magnet contact at all times.

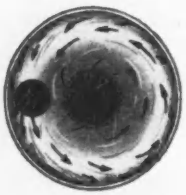


MAGNET SECTION: The other of the two parts for either Clutch or Brake units. Consists of electro-magnet faced with long-wearing, high friction material. Power, applied through coils imbedded below (see cut), uses both friction *plus* magnetic attraction for fast, super-powerful clutch or brake action.

● Warner ICB Units* are low-cost key to more automatic, safer operation of wide variety of motors and machinery . . . give you infinite control of degree of clutch or brake action. For details or engineering assistance write: INDUSTRIAL DIVISION, WARNER ELECTRIC BRAKE MFG. CO., Beloit, Wis.

***ICB Unit — The trade designation for the Warner Electric INDUSTRIAL CLUTCH OR BRAKE UNIT.**

Keep big troubles OUT by designing this small air filter IN!



TORNADO JET ACTION imparts swirling motion that throws moisture against wall.

BAFFLE PLATE divides bowl into "Active Zone" where separation takes place and "Quiet Zone" into which moisture drops.

TRANSPARENT BOWL shows the filtering action and condition of air line. Tells operator when to drain bowl.

Corrosive moistures and emulsions as well as abrasive dirt, pipe scale, and other impurities mean excessive wear and faulty performance of air tools and air-actuated components of machine tools.

Lick this big trouble right on the drawing board! Put NORGREN air-line FILTERS in the specifications—without changing your designs.

NORGREN Replaceable Bowl Filters have many worthwhile features that will interest you: — Automatic operation; No moving parts; Directional air inlet provides centrifugal filtering action; Baffle plate traps moisture in bottom of bowl; Reinforced Monel wire filter screen stops solids. These and other features add important selling advantages to the air-operated equipment you design. Write for details. C. A. Norgren Co., 222 Santa Fe Drive, Denver 9, Colorado.

VITALIZER UNITS (Filter-Lubricator)

LUBRO-CONTROL UNITS (Filter-Regulator-Lubricator)

Norgren

Lubricators, Regulators, Filters, Valves, other Air Controls, Hose Assemblies.

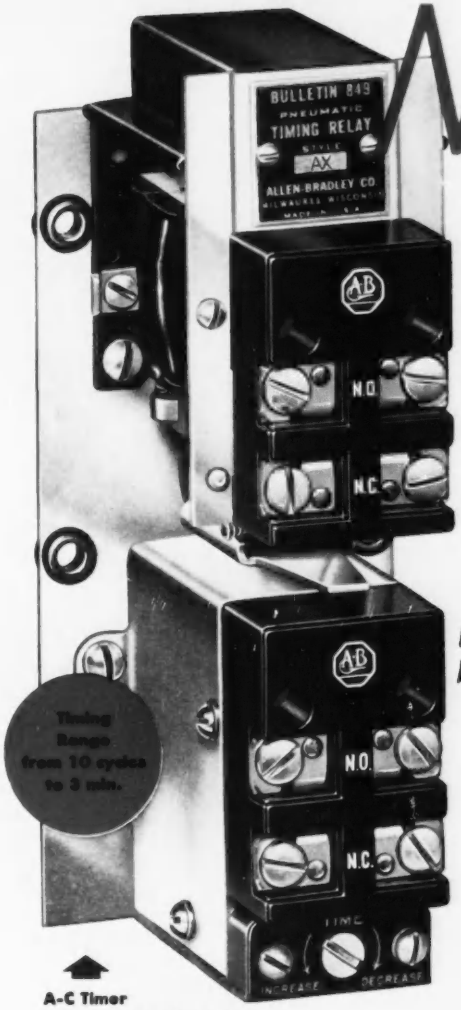
WHEREVER AIR IS USED IN INDUSTRY

NEW...

Bulletin 849

PNEUMATIC TIMING RELAY

Good for Millions of Operations



A-C Timer with Auxiliary Contacts

D-C Timer

- FOR "DASH UP" OR "DASH DOWN" OPERATION
- AVAILABLE FOR NEMA TYPE 1, 4, 7, and 9 APPLICATIONS

This new, compact, solenoid type, pneumatic timing relay utilizes a synthetic rubber bellows for controlling the tripping time. Has a range of from 10 cycles to 3 minutes, and an accuracy of approximately ±10%. Its setting is easily adjustable over a wide range, and the relay resets instantaneously. This timer will provide satisfactory operation irrespective of temperature, humidity, or vibration conditions. Available with quick make and quick break, double pole, silver alloy main contacts—one set normally open and one set normally closed. Terminals are readily accessible from the front. A duplicate set of contacts for pilot control can also be provided, actuated directly from the solenoid. The unit can be readily changed from "dash up" to "dash down" operation by simply inverting the solenoid. Write for information on this new Bulletin 849 Pneumatic Timing Relay.

ALLEN-BRADLEY CO.
1316 S. Second St., Milwaukee 4, Wis.

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

A-B Quality

OTHER RELIABLE TIMING RELAYS

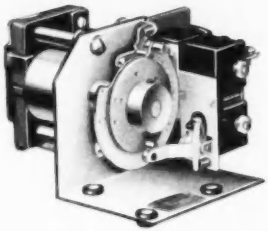
TO FIT YOUR REQUIREMENTS

BULLETIN 850
MOTOR DRIVEN TIMING RELAY

Designed for timing comparatively long intervals with a high degree of accuracy where high speed recycling is not required. Furnished in several ranges with a maximum time delay of from 1 to 15 minutes. Variations in time between successive operations are less than 1% of the full scale range. Its synchronous motor is suitable for a-c pilot control service only. Has a single pole switch for normally open or normally closed operations.

BULLETIN 850
TYPE L LAUNDRY TIMER

Similar in design to the Bulletin 850 Motor Driven Timing Relay, this timer is specially designed for controlling washing machines and other equipment where the motor is run for a given period in one direction, reversed, and then run in the opposite direction.



BULLETIN 852
ELECTRONIC TIMING RELAY

Designed primarily for exact timing in frequent operation. It has a range of 20 to 1 and is provided in eight timing ranges with from ½ second up to 2 minutes maximum time delay. The reset time is approximately one-tenth of the maximum time delay. This is a flexible timer that can be recycled rapidly over long periods. Furnished with two normally open, two normally closed, or one normally open and one normally closed contacts.

BULLETIN 848
FLUID DASHPOT TIMING RELAY

Here is a magnetic type timing relay that combines simplicity, dependability, and low cost. It can be used in many applications where reliability is more important than exactness of timing. Operates at ambient temperatures from +120 F to −30 F without undue variations in timing. Has an adjustable range from 2 to 20 seconds and is available for a.c. or d.c. . . . in single pole construction . . . with either normally open or normally closed contacts.

ALLEN-BRADLEY

MOTOR CONTROL

Write for New Timer Bulletin

Allen-Bradley Co.,
1316 S. Second St.,
Milwaukee 4, Wis.

YOU GET CORROSION RESISTANCE

Plus ECONOMICAL TROUBLE-FREE FORGINGS

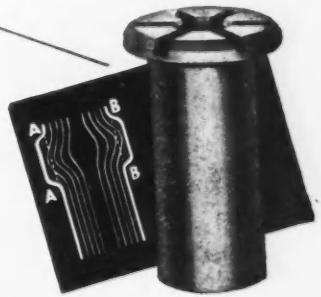
WITH *Carpenter* STAINLESS

POSITIVE PROTECTION against corrosion to withstand the effects of repeated sterilization, plus the required strength and hardness, made Stainless a natural choice for this forged dental instrument. Clean, flawless Stainless forging bars reduced rejects, increased output.

If rejects run high when forging Stainless, it's time to check all along the line. Many factors must be controlled right in the forge shop. But to eliminate trouble and secure best results you must be sure that your forging bars are sound, clean and free from injurious surface defects. Such forging bars assure easiest forging operations and lowest production costs.

At Carpenter, Stainless Steels are made in a tool steel mill to tool steel quality standards. Stainless billets are disc-inspected to assure soundness and homogeneity—and are then *machine-turned* to remove all surface imperfections. By this painstaking process we end up with Stainless bars that, lot after lot, assure economical, trouble-free forgings.

You'll find your nearby Carpenter representative extremely helpful when it comes to finding ways and means of applying Stainless to your products. Back of him stands a company with years of practical experience in solving Stainless problems. Call him in today or write us at the mill . . . And for your copy of our 134-page book "Working Data for Carpenter Stainless Steels" drop us a note on your company letterhead, indicating your title.



LONGER LIFE. In spite of tremendous pressures and highly abrasive conditions in service—forged knuckle pins like this stay on the job longer because they are made from Carpenter Stainless. And note in the diagram that forging produced an even grain flow throughout, thus strengthening the thin sections at points AA and BB.

THE CARPENTER STEEL COMPANY • 117 W. Bern Street • Reading, Pa.

Export Department: 233 Broadway, New York 7, N.Y."CARSTEELCO"

Carpenter

FORGING QUALITY

STAINLESS STEELS

WHEN YOU HAVE A STAINLESS PROBLEM—YOU CAN COUNT ON CARPENTER FOR THE ANSWER

M=PT ... BASIC FORMULA FOR DESIGN ENGINEERS

Apply this basic formula, M=PT (Morse means Power Transmission), and you'll get:

1. An unmatched line of silent and roller chain drives, clutches and couplings. Wide range of sizes, capacities and ratings in stock.

2. The economies of mass-production with automatic machinery—*a lower cost for you.*

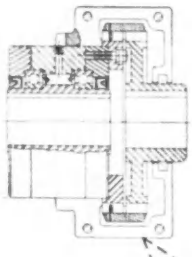
3. Power transmission products backed by a 51-year record of specialization in precision engineering and mechanical craftsmanship.

4. The application experience of Morse Power Transmission engineers—partners in the design and development of a very great variety of products.

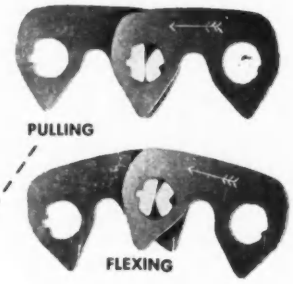
And you get the *extra margin of profit* that results from buying all your power transmission equipment from a single source—the leader in power transmission. Morse Chain Company and Morse Chain Distributors.

Keep your catalog file up-to-date! Send coupon for latest data and specifications on Morse Roller and Silent Chain Drives, Clutches, Couplings and Driveshafts.

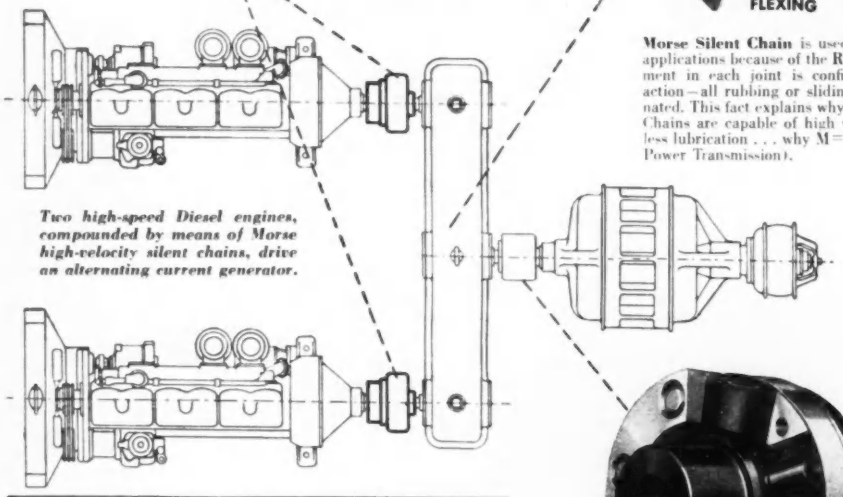
Typical Application of Morse Power Transmission Products



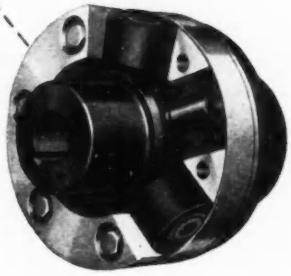
Morse-Formsprag Clutch Couplings combine full complement Morse-Formsprag over-running clutches and Morse flexible couplings. The over-running clutch automatically engages when torque is applied—disengages when torque ceases. The automatic action is instantaneous to protect equipment in the event of failure of either engine. Morse flexible couplings compensate for misalignment.



Morse Silent Chain is used on high velocity applications because of the Rocker Joint. Movement in each joint is confined to a rocking action—all rubbing or sliding motion is eliminated. This fact explains why only Morse Silent Chains are capable of high velocities—require less lubrication . . . why M=PT (Morse means Power Transmission).



Two high-speed Diesel engines, compounded by means of Morse high-velocity silent chains, drive an alternating current generator.



Morse Morflex Radial Couplings with resilient, preloaded rubber "biscuits" are ruggedly constructed, and torsionally flexible. Morflex Radial Couplings compensate for misalignment, absorb shock and dampen vibration. These qualities result in smooth, vibration-free power transmission. M = PT (Morse means Power Transmission).

ASK the Morse Man nearest you . . . today!

From coast to coast there are more than 100 offices, representatives and distributors of Morse Power Transmission products to give you quick information and service when you want it—where you want it. *Ask the Morse Man first in any case!* **Check your classified telephone directory under "Power Transmission" or "Chains."**

Morse *means* Power Transmission

Morse Roller Chain Couplings

Morse Silent Chain Couplings

Morse Morflex Couplings

Morse Morflex Radial Couplings

Morse Morflex Drive Shafts

Morse-Formsprag Clutches

Morse-Rockford Clutches

Morse-Rockford Pullmore Clutches

MORSE
MECHANICAL
POWER TRANSMISSION
PRODUCTS

PRODUCTS OF B-W BORG-WARNER

Morse Chain Company
7601 Central Avenue, Dept. 419
Detroit 8, Michigan

Gentlemen:
Please send me latest technical data and specifications on:

- ☐ Roller Chains and Sprockets
- ☐ Silent Chains and Sprockets
- ☐ Morse Silent and Roller Chain Couplings
- ☐ Morflex Couplings
- ☐ Morse-Formsprag Clutches
- ☐ Morse-Rockford Clutches
- ☐ Pullmore Clutches
- ☐ Have representative call

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

TORQUE
Wallace Barnes Springs
Bristol Connecticut

HOW TO SOLVE HIGH TEMPERATURE PROBLEMS

Appliance designers agree that most high-temperature problems fall into two broad classifications . . . (1) where operating temperatures range up to 650°F. (2) where they exceed 1000°F.

In the 400° to 650° range, commonly experienced troubles are spring relaxation and corrosion. At higher temperatures, destructive oxidation, embrittlement, and heat-softening become serious threats.

Many prominent manufacturers have found that *both* high and low heat problems can be solved dependably with the versatile Inco Nickel Alloys. Each of these individualized "task metals" offers special advantages *in addition* to remarkable resistance to corrosion and destructive oxidation.

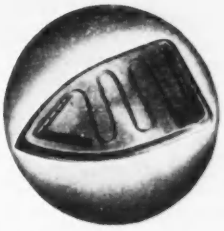
*Monel**, with the strength of structural steel, withstands temperatures of 1000°F. *"K"** *Monel* offers greater hardness through heat-treatability. *Inconel** withstands temperatures up to 2000°F., and is relatively unaffected by corrosive atmospheres that rapidly destroy ordinary metals.

Still other Inco Nickel Alloys . . . "R"* Monel, "KR"* Monel, Duranickel*, Permanickel* . . . offer special properties that help electrical manufacturers solve difficult design problems.

If you would like to see how other manufacturers are using Inco Nickel Alloys to improve their products, write for *"66 Practical Ideas for Metal Problems in Electrical Products."* This lavishly illustrated 36-page booklet may suggest a solution to some of your own engineering and manufacturing problems. Send for it . . . today.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

*Reg. U. S. Pat. Off.



TUBING THAT RESISTS HEAT

Steam iron tubing calls for easy-to-form, rustproof metal . . . resistant to oxidation at operating temperatures up to 550°F. McCracken and Daniels Co., makers of steam-electric irons, found that rustless, corrosion-resistant "L" Nickel tubing (¼"O.D.x.028" wall) provides essential hot strength and may be cast right into the sole plate without warping or collapsing.

In many other makes of irons a difficult high temperature problem—thermostat springs—is solved by use of Inconel.

CONNECTORS THAT STAY TIGHT

Appliances fitted with these solid Nickel heat-resistant connectors, face no danger of oxidation, embrittlement or softening when operating at 1900°F. Produced by Thomas & Betts Co., Inc., these connectors are permanently affixed to flat ribbon, solid round or stranded wires by the tool shown.

HEATING UNITS THAT LAST

Hundreds of thousands of Inconel sheathed heating-units are in use today. Many have been on the job for 10 years—and longer. Inconel sheaths resist corrosion from spill-overs, and remain free from warping, scaling and cracking. Inconel gives much longer life than material used on earlier units. That's why range manufacturers standardize on Inconel for sheathing.

FEWER LEAD WIRE BURN-OUTS

Stop customer complaints and dealer dissatisfaction . . . by using lead wires that resist oxidation and high-temperature deterioration. Appliance makers use nickel wires, made by Rockbestos Products Corporation, to assure trouble-free service and excellent conductivity.

NICKEL (INCO) ALLOYS

Monel • "K" Monel • "R" Monel • "KR" Monel • "S" Monel • Nickel • "D" Nickel • "L" Nickel • Duranickel • Permanickel • Inconel • Inconel "X"

WHEN TO USE SINGLE ROW RADIAL

VACUUM SEAL BALL BEARINGS

If your application calls for a sealed bearing able to take combined radial and thrust loads in any direction—and the outer ring is to be stationary—Federal Single Row Radial Vacuum Seal Ball Bearings hold the answer to your problem.

These bearings, whose load ratings are identical with Federal Conrad Type Bearings, provide an absolutely effective seal without felt, cork or fillers of any kind. A metal impeller, secured to the inner ring, keeps the lubricant in the vital bearing parts by centrifugal force. An outer plate, fitted into a groove in the outer ring, completes the seal. These design features assure smooth, quiet operation and completely eliminate noise, heat and sliding friction.

Federal Vacuum Seal Ball Bearings are ideally suited for electric motors and generators, and many other industrial applications where effective sealing is necessary.

You'll find complete specifications and load rating tables for these and all other Federal Bearings in our Catalog "K." It describes every type and size bearing, shielded and sealed...for every anti-friction need. Its 260 pages of ball bearing information, including selection charts, will help you compute bearing loads, determine capacities at every speed, and choose the type and size bearing best suited to your individual need. Write today for your copy.

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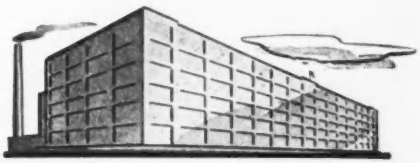
HOLTZER CABOT

FINE ELECTRIC MOTORS FOR PRECISION INSTRUMENTS



If you are searching for supreme accuracy in instrument motors, look to the noted electrical engineering facilities and modern streamlined manufacturing plant of Holtzer-Cabot. Type R-25, either synchronous or induction, Holtzer-Cabot motors and gear head units power many of the world's finest instruments. Motors are in sizes up to 1/500th horsepower, gear head outputs down to 1 r.p.m. Many models can be secured from stock, or they can be built to special order. Write for complete information.

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AFFILIATED WITH REDMOND COMPANY, INC.

BOSTON 19, MASSACHUSETTS

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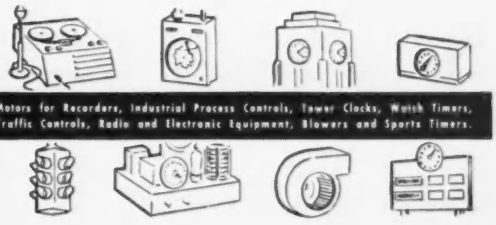

Motors for Recorders, Industrial Process Controls, Tower Clocks, Watch Timers, Traffic Controls, Radio and Electronic Equipment, Blowers and Sports Timers.

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HIGH-TENSILE

Mayari R

...fabricated like carbon steel

Because of the higher properties of Mayari R low-alloy, high-tensile steel, some designers assume it is much harder to work with than carbon steel. Not so.

Experience of many Mayari R users shows that the same equipment and same methods used for forming, punching, shearing and welding ordinary carbon steel usually work well with Mayari R. The only difference is that slight adjustments or allowances may be needed to offset Mayari R's higher properties.

This means that users can take advantage of Mayari R's higher yield-point, greater tensile-strength, and superior corrosion-resistance in their products without the burden of excessive fabricating costs.

Mayari R is now used in products ranging from electric flatirons and domestic washing machines to truck trailers and highway bridges. For more information on this versatile steel, its advantages and applications, write for a copy of Catalog 209.

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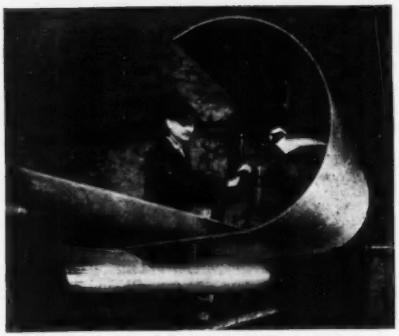
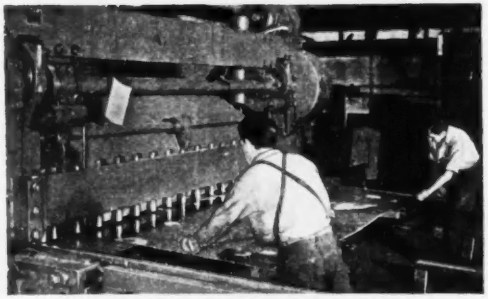
On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

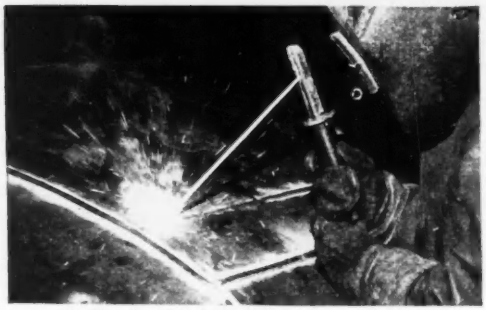


Roll-bending Mayari R sheets for cylindrical products



Shearing heavy-gage Mayari R sheets to size

Cold-forming channel sections from Mayari R



Welding Mayari R with ordinary electric-arc equipment

Mayari R *makes it lighter...stronger...longer lasting*

enclosed gear drives...

for every industrial need!

Foote Bros. Hypower Worm Gear Drives, both horizontal and vertical types, offer new economies in space, weight and cost. Increased load-carrying capacity is accomplished by a revolutionary technique in generating gears. The oil bath is cooled by passing a high velocity stream of air through an air channel cylinder immersed in the bath. This provides greatly increased thermal capacity.

Foote Bros. Hygrade Worm Gear Drives are available in a wide variety of types. This line is newly designed and includes sizes and ratios to meet practically any requirement.

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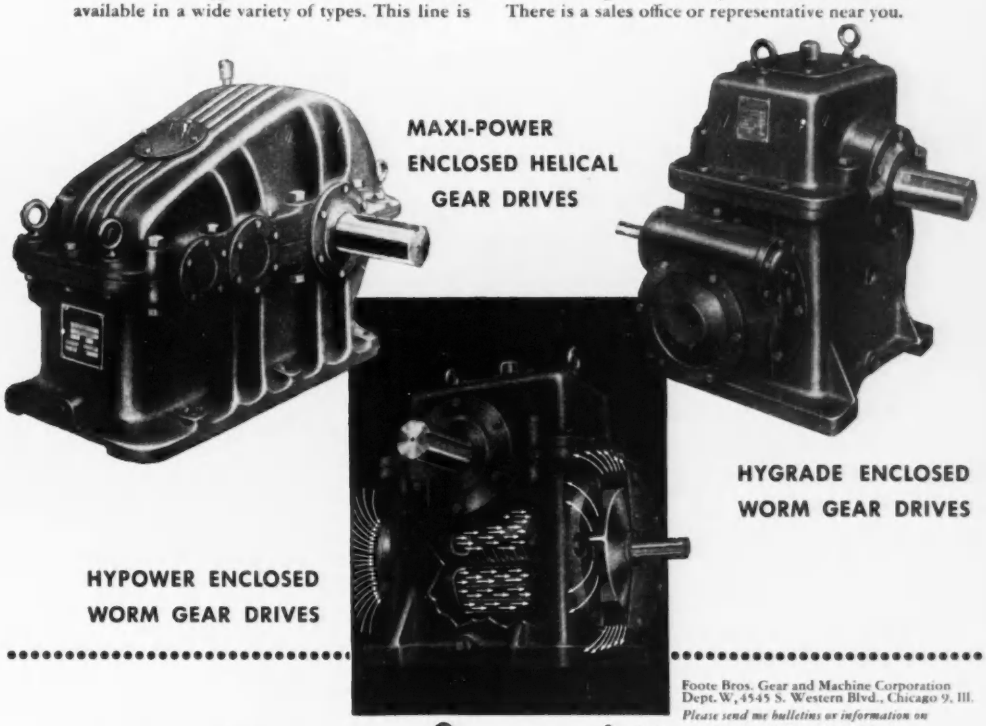
Regardless of what your requirements in gears or enclosed gear drives may be, call on Foote Bros. There is a sales office or representative near you.



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Better Power Transmission Through Better Gears

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Dept. W, 4545 South Western Boulevard • Chicago 9, Illinois

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Please send me bulletins or information on

- ☐ Hypower Enclosed Worm Gear Drives
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Play "close harmony" with musical instrument makers in <u>both</u> these vital ways...

1. "Sweet Music" in Production: Never a "sour note" of spoilage, delay or accident where these automatically straight-driving American Phillips Screws are used in assembly. Costly materials and hours of skilled workmanship are never wasted or lost. To the contrary, American Phillips Screws combine speed with precision so that *fastening time is cut 50%*, even on the fussiest work.

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Only a few years ago, a man who proposed to use adhesives in any of the ways pictured above would have been called "visionary." But not today. Armstrong's Adhesives already have made two of these three uses entirely practical. The third promises to be possible soon.

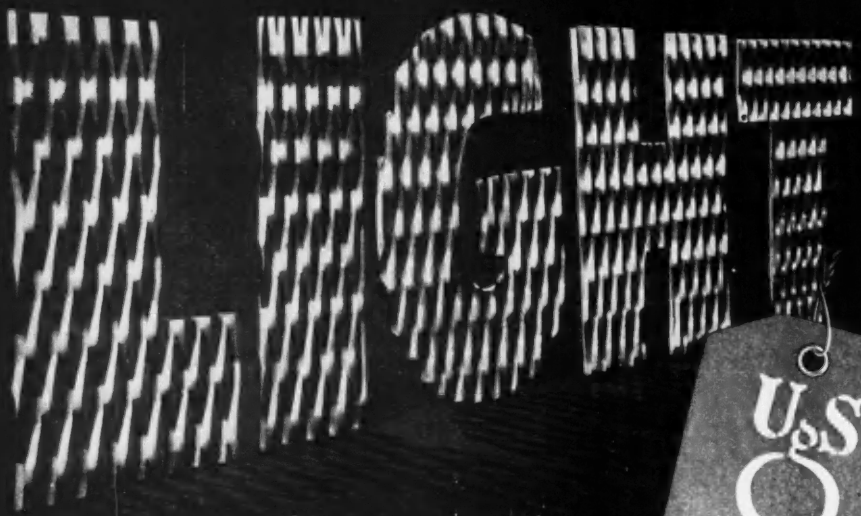
It's a good thing to keep the versatility of modern adhesives in mind, particularly when you're probing for workable ways to improve a product or lower its cost. The right adhesive may help you do both. It's a possibility worth talking over with us, in any event.

Chances are that you have had assembly ideas that you've rejected promptly as being too visionary. We'd like to study just such ideas, even if no adhesive with the properties you require has ever been made. The means of putting your idea to work may already be outlined on the pages of our lab notebooks. Call the Armstrong Cork Co., Industrial Adhesives Department, 6809 Arch Street, Lancaster, Pennsylvania.

ARMSTRONG'S ADHESIVES

by the makers of Armstrong's Linoleum

Make it



Make it stronger . . . BETTER

...the Material of 1000 Uses

Made from a solid sheet of metal—slit and expanded—EXPAND-X is lighter per square foot than the original sheet—yet is sturdy enough for years of service. It also has greater resistance to bending, permits ready passage of light and air.

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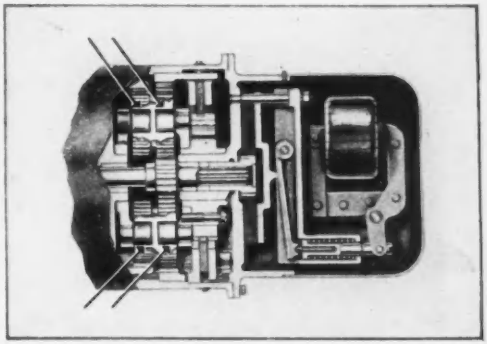
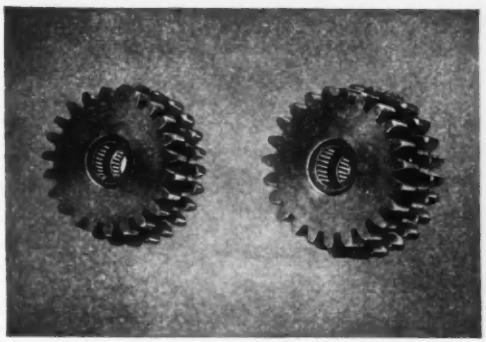
Gypsum • Lime • Steel • Insulation • Roofing • Paint

Torrington Needle Bearings Give Smooth, Reliable Service in Harnischfeger P&H Zip-Lift Hoists

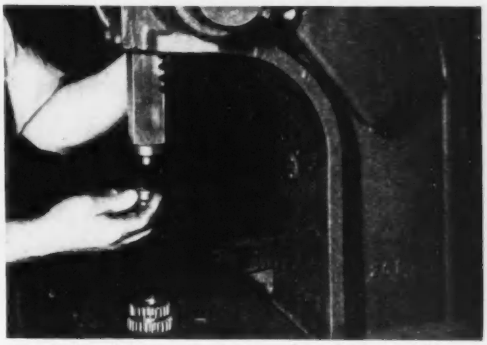
Lifting, lowering and spotting loads is made easy with a P&H Zip-Lift Electric Hoist. Harnischfeger Corporation makes sure that hoist service is reliable, too, with compact, high-capacity Torrington Needle Bearings in the Zip-Lift Drive.



This planetary gear drive incorporates all the best principles of power transmission with a minimum of parts. Needle Bearings provide high radial load capacity in minimum space in the planetary gears. High efficiency is secured with wear practically eliminated.

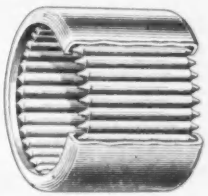


The use of two Needle Bearings per gear gives them unusual stability. The turned-in lips of the bearing shell conserve lubricant. These features keep planetary drive gears running smoothly and quietly with minimum lubrication and maintenance attention.



Installation of the bearings is as simple as the design. They are pressed quickly into place on an arbor press. Both bearings can be installed in one operation with suitable tools. And since Needle Bearings take a firm press fit, no spacers or retainers are needed.

Design *simply* for anti-friction efficiency, high load capacity, effective lubrication and easy installation with Torrington Needle Bearings. Let our engineers combine their experience with yours for profitable results. Write us today. THE TORRINGTON COMPANY, Torrington, Conn., or South Bend 21, Ind. District offices and distributors in principal cities of United States and Canada.



TORRINGTON *NEEDLE* **BEARINGS**

Needle • Spherical Roller • Tapered Roller

Straight Roller • Ball • Needle Rollers

YOU CHOOSE DEPENDABILITY

QUALITY, SERVICE, VENDOR'S REPUTATION AND PRICE

- ★ These are points you gentlemen in engineering carefully check and compare.
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- ★ By your decisions industry grows and America prospers.
- ★ At your service are hundreds of engineers and a corps of research scientists.
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☐ OIL-CUSHIONED BEARINGS ☐ FINISHED MACHINE PARTS ☐ PERMANENT FILTERS ☐ CORED AND BAR STOCK

Horatio Alger's Hero in Washington

AN AMBITIOUS YOUNG MAN got a job in a government bureau and vowed he would rise high as a career man in Washington. Naturally, because all beginnings should be small, the position was a modest one. He was given full charge of four girls whose job it was to type statistics.

According to the story, and it is claimed to be true, it was only a day or two before our hero learned all about the essential ingredient for a highly paid, respected, influential position with our government. He found that his pay, to say nothing of his ego, rose in proportion to the number of employees under his jurisdiction.

But only a pitifully few girls, four to be exact, were needed to do the job even in a leisurely manner. An unambitious man would have accepted this fact as a permanent block to his progress. But not so our hero. He was made of more brilliant stuff. As far as he was concerned his department was going to grow or bust, so he at once started to give it the necessary growth nourishment.

His first step was to issue a "directive" that there would be a conference every morning as soon as the girls came back from the coffee shop. This conference lasted till noon. The next directive was to the effect that immediately after lunch the girls were to make out their list of "Work to be done," following which they were to make written reports on "Status of jobs in progress."

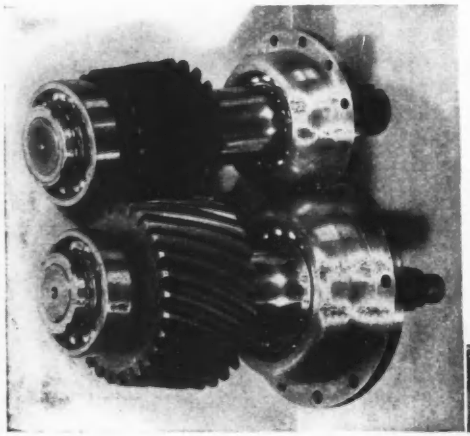
The work piled up. The big boss frowned. Our hero pleaded for more help to get the towering mass of correspondence moving. He got the help. Then it was decided that an index, cross indexed by title, dates, subjects, etc. was needed. More files, more girls—progress. When the number of girls reached 29, which included private secretary, receptionist and assistant office manager, our hero got his raise, and a nice one at that. He had learned fast and was fittingly rewarded for the brilliance he had demonstrated.

Now, we all admit that industry is just the opposite from government. The former rewards the employee who builds a record for economical operation and whose department shows a profit, directly or indirectly. Now is a psychological time to ask yourself, "Do we really need all those records? Have the indexes proved their value by actual use? Is that extra carbon copy really necessary? Could we not get rid of some of those musty filing cabinets?" And how about those long winded conferences that start from nothing and get nowhere? And why not tell a guy to get it done instead of putting it up to a committee? And finally, consider those wonderful typewritten memos that give you such a feeling of importance.

Try bawling out the gang once in a while in a nice sort of way instead of issuing a "directive" that must be typed, checked, distributed and read, and then filed.

G. F. Rodenhoff

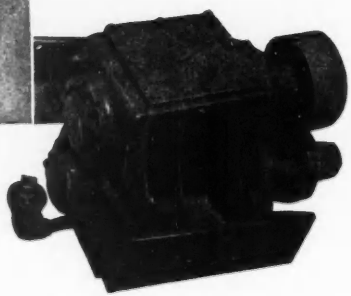
Vee Drive Ball Bearings outlast 2 pairs of engines!



The New Departure ball bearings supporting these spiral bevel gears take heavy thrust and radial loads, but they never require adjustment for wear.

The New Departure ball bearings in the original Vee Drive gear box for Huckins Engines-in-stern yachts, installed 15 years ago, have never required replacement or adjustment—*have outworn two pairs of engines.*

This is the kind of performance that *keeps* New Departures regular equipment in these drives—and, it is typical of the rugged dependability that all builders of fine machines or equipment need for their products in the times ahead.



Vee Drive Gear Box used in Fairform Flyer Yachts with Engines in the stern.

Nothing Rolls Like a Ball

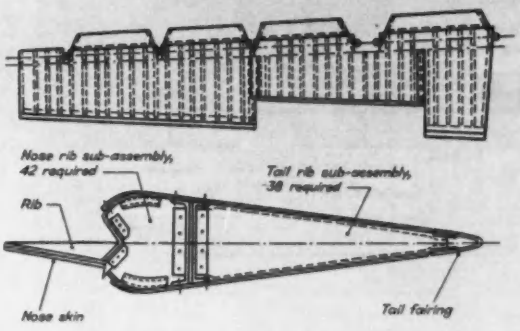
NEW DEPARTURE
BALL BEARINGS

70

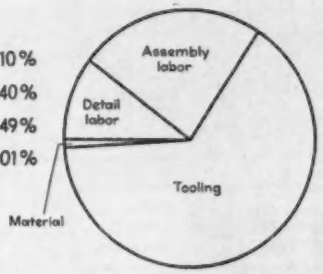
NEW DEPARTURE • Division of GENERAL MOTORS CORPORATION • BRISTOL, CONNECTICUT • BRANCHES IN ALL PRINCIPAL CITIES

DISTRIBUTION OF MANUFACTURING COST OF AN AILERON FOR A MODEL P4M AIRPLANE

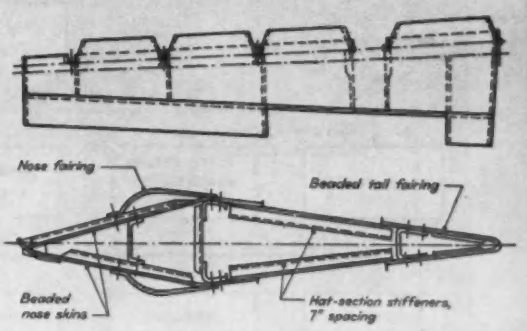
PROTOTYPE DESIGN
Multiple Detail Design, 428 Parts



Detail labor 10.10%
Assembly labor ... 23.40%
Tooling 65.49%
Material 1.01%



PRODUCTION DESIGN
Composite Detail Design, 329 Parts



Detail labor 6.2%
Assembly labor ... 19.6%
Tooling 41.2%
Material 1.2%

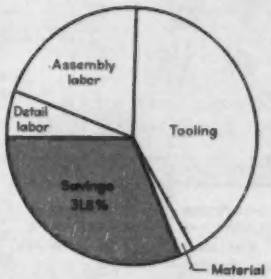
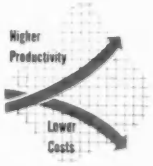


FIG. 1

Organization and Operation . . .

Design Cost Control



JOHN VAN HAMERSVELD
Senior Cost Analyst, The Glenn L. Martin Company

Operational functions, duties and relationship of design cost control engineers in collaborating with design engineers to achieve design releases for profitable product manufacturing. Four methods of making a fitting are cost-analyzed to show how design cost control operates in arriving at a design decision for maximum economy in manufacturing.

INCREASING COMPLEXITIES of modern design necessitate the services of a new group of engineering specialists to design quality products that can be sold in today's competitive markets. This group of design cost control engineers specialize in producibility and costs. They collaborate with the designers to develop economical design procedures and techniques.

How closely the factory can approach minimum cost of fabrication will be determined by the controlled effectiveness of manufacturing, tooling, purchasing and planning. But the most efficient manufacturing methods, tooling designs, planning procedures and purchasing techniques cannot lower the cost of fabrication below the basic structure established by the design engineer.

Since design cost control is the efficient application of comparative manufacturing techniques affecting weight, stress and functional design to obtain economical production, the design cost control group's basic functions should include:

1. Cost-analyze engineering designs and initiate production design principles to obtain the most economical design decision for manufacturing.
2. Promote cost control by the issuance of design bulletins presenting design cost reduction procedures.
3. Develop the standardization of

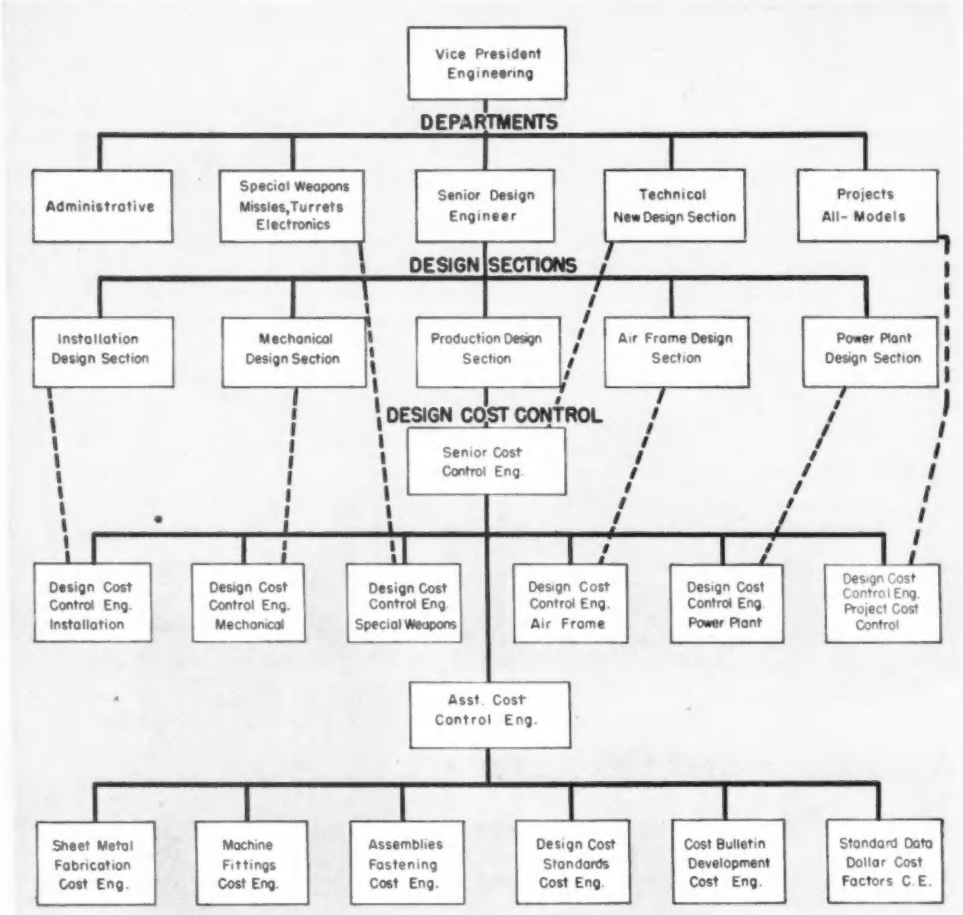

Vice President Engineering
DEPARTMENTS
Administrative
Special Weapons Missles, Turrets Electronics
Senior Design Engineer
Technical New Design Section
Projects All- Models
DESIGN SECTIONS
Installation Design Section
Mechanical Design Section
Production Design Section
Air Frame Design Section
Power Plant Design Section
DESIGN COST CONTROL
Senior Cost Control Eng.
Design Cost Control Eng. Installation
Design Cost Control Eng. Mechanical
Design Cost Control Eng. Special Weapons
Design Cost Control Eng. Air Frame
Design Cost Control Eng. Power Plant
Design Cost Control Eng. Project Cost Control
Asst. Cost Control Eng.
Sheet Metal Fabrication Cost Eng.
Machine Fittings Cost Eng.
Assemblies Fastening Cost Eng.
Design Cost Standards Cost Eng.
Cost Bulletin Development Cost Eng.
Standard Data Dollar Cost Factors C.E.

Fig. 2—Organization and function of design cost control group to the engineering division at The Glenn L. Martin Company.

designs for economical manufacturing.

4. Initiate and cost analyze new manufacturing procedures.

5. Encourage and develop a cost conscious attitude toward design problems. The operational techniques of design cost control take time and money, and may at times slow down the pace of designing. But at The Glenn L. Martin Company there is no doubt that it is a good investment; particularly when design cost control decisions for the last year's activities indicated a potential savings of over $1,600,000. The manpower expenditure approximated only $30,000 for this activity.

A typical example of the designers influence on the distribution of manufacturing cost is shown by the pie charts of Fig. 1. The charts indicate percentage costs for detail labor, assembly labor, tooling and material for a prototype aileron and for a redesigned production version. The designer saved by effective design control approximately 4 percent detail labor, 4 percent assembly labor, and 24 percent tooling; and lost about 0.2 percent material cost. These items result in a direct saving of 32 percent of the manufacturing cost.

The functional relationship of the design cost control group with the engineering departments and design sections at The Glenn L. Martin Company is indicated in Fig. 2. The group functions in a consulting capacity through the production design section, which in turn reports to the senior design engineer. The design cost control group is divided into two units.

The first unit, composed of design cost control engineers located in the various design and department sections, is primarily responsible for providing "on the spot" design cost information. Since this function is the most important one of the cost group, it is under the personal supervision of the senior cost control engineer. Specialists in their fields, the personnel in this unit collaborate with design engineers to achieve economical design releases for manufacturing.

The second unit, composed of cost engineers under the assistant cost control engineer, is responsible for the basic development of standards such as cost bulletins, dollars cost con-

version factors, time data and basic analyses. Some of these standards are incorporated in the Production Design Bulletins described in "Designing With Dollars," PRODUCT ENGINEERING, March 1948, p. 81. This unit furnishes the design cost control engineers with supplemental data and assists in the evaluation of comparative cost analyses requiring development or lengthy investigations.

Group concentration is thus established on design problems that results in many suggestions to achieve economical solutions. Also, the detail duties of the design cost control engineer are minimized so that daily contacts with design personnel can be carried out with maximum efficiency. The personnel of each unit are specialists in the fields of manufacturing processes, cost accounting, production design engineering and industrial engineering techniques.

The operational functions, duties and qualifications of the design cost control engineers are:

Functions

1. Maintain design economy by routine check of design layouts in his division.

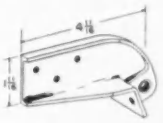
2. Evaluate controversial designs by determining the most economical designs through the use of design bulletins covering cost reduction principles.

3. Initiate, Develop and Cost Analyze: (*a*) Design economy standards, (*b*) comparative cost studies, (*c*) new manufacturing procedures, and (*d*) economical engineering designs.

4. Control design changes to keep scrap loss and manufacturing costs to a minimum.

5. Maintain constant surveillance of possible production "bottle necks" caused by insufficient design study.

6. Maintain a cost savings schedule.



COMPARATIVE COST SUMMARY SHEET MODEL: P4M-1

TITLE: FITTING ASSY. - MAIN GEAR OLEO DOOR AFT. HINGE

DRAWING NO: 20-21-0715

ANALYSIS: 24ST Machined Bar Stock - VS - 24ST Machined Forging - VS Welded Fitting H.T. to 125,000 P.S.I. - VS - Al. Alloy Casting Class "A"

PREMISES: Total of 100 parts. Production lots of 25 parts per lot. Tool & labor hours were coordinated with representatives from Tool Engineering & Detail Manufacturing.

SUMMARY:

ITEM	BAR STOCK		FORGING		WELDED		CASTING CLASS "A"	
	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST
MAT'L		1.36		0.58		0.18		0.30
PURCHASED EQUIPMENT								
FIXED TOOLS DETAIL	19.51	0.19	19.51	0.19	50.19	0.50	19.51	0.19
FIXED TOOLS ASSEMBLY								
DETAIL SET-UP	14.67	0.59	8.65	0.35	18.86	0.75	8.65	0.35
DETAIL LABOR		8.85		2.18		2.76		2.18
ASSEMBLY SET-UP								
ASSEMBLY LABOR								
DIE			708.75	7.09				
PATTERN							48.00	0.48
ENGINEERING COST								
SPEC. TEST							442.40	4.42
TOTAL UNIT COST		10.99		10.39		4.19		7.92
UNIT WEIGHT	0.229 LBS.		0.321 LBS.		0.437 LBS.		0.417 LBS.	

REMARKS: As indicated by the above figures, the welded fitting proves to be the most economical to manufacture, however, to realize this savings a weight penalty of 0.208 LBS/PART would have to be accepted.

ACCEPTANCE OF COST DESIGN DECISION: DATE:

PREPARED: DATE: APPROVED:

Fig. 3—Cost summary sheet taken from design cost bulletin "Design for Economy".

Duties

1. Study and evaluate design layouts to determine whether a cost investigation is necessary and justify the expense of making an analysis.

2. Determine the analyses that may be analyzed superficially and those that need detail coverage.

3. Provide the basic cost development group with all necessary information pertaining to design studies and coordinate between design and development group.

4. Perform satisfactorily the duties of the basic development cost engineer, which include: (*a*) Detail manufacturing operations, (*b*) application of standard data, (*c*) conversion of time values to standard dollars, (*d*) summarize and execute a comprehensive report, (*e*) develop standard data by compilation or time study, and (*f*) develop standard dollar factors by evaluating fatigue allowance, take-away rate, overhead percentage and learning cycle curves.

5. Be responsible for the execution of superficial on-the-job analyses.

6. Maintain an up to the minute knowledge of latest practices in production, tooling, manufacturing, accounting, industrial engineering and cost control.

Qualifications

1. Fundamental knowledge of engineering principles with the ability to suggest practical design improvements and to understand the principles of stress and weight analyses that may be required to bring about such improvements or recommendations.

2. Specialist in the application of production design principles and the solution of producibility problems.

3. Excellent judgment in the use of standard time data per operation and labor cost factors to cope with the many variables in development of cost analyses.

4. Ability to understand the techniques of cost accounting in the use of wage rates, burden charges and cost procedures.

5. Thorough understanding of the function of all types of machines and tools required in manufacturing.

6. Excellent engineering English to

compile clear readable reports and make understandable recommendations for cost developments.

7. Good mathematical abilities to develop cost factors, quantity cost curves and statistical records of design costs.

8. Excellent aptitude for presenting visually the development of cost breakdowns and design simplification principles.

To obtain men with these qualifications on the open market is almost an impossibility. But a design cost control group can be successful with men who have fundamental engineering knowledge and sufficient practical shop experience. With these two basic requirements, men can be trained in the fields of industrial engineering, cost accounting and report writing.

Operational policies of the cost control engineer are of paramount importance, since he functions in a consulting capacity throughout the engineering organization. He must, therefore, be able to:

1. Cooperate and coordinate his efforts with those of the project and group engineers in the basic design sections.

2. Convince others that cost ideas, attitudes, designs and philosophies are basically sound and essential to economical manufacturing procedure.

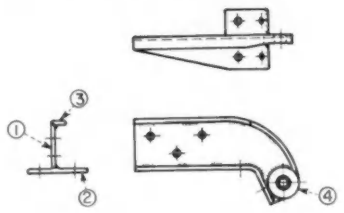
3. Avoid dominance, argument and forcefulness in presenting cost problems.

4. Present or convey cost problems and suggestions in a manner such that the designer or draftsman acquires the impression that he has solved the cost decision by his own volition or initiative.

Fundamentally, the design cost control engineer sells his wares by dollars and cents—cost figures usually sell any article no matter how nicely a salesman may expound. Human nature reacts to "How much does it cost," in comparing products. The habit of comparing dollar and cents values of of one design with respect to another can solve many costly design inertias, which are so often prevalent throughout engineering organizations.

Coordinating the development of comparative cost analysis with the various plant departments is another specific function of the cost engineer. Depending on the nature of information required to determine cost decisions, his contacts are with these departmental groups: Tool engineering planning, manufacturing processes, purchasing equipment and material, production schedule control, standard parts and processes, and inspection control.

4130 WELDED STEEL



Web—(1) Material 0.091 x 2¾ x 4¾ at $0.635/sq ft = $0.091

Set-Up	Run Time	Operation
12.00	0.050	Shear to Length
	0.540	Layout and Scribe
5.00	0.850	Saw to Profile
	1.870	Chamfer 3 sides
	0.150	Check by Operator
17.00	3.460	Total Minutes

Flange—(2) Material 0.091 x 1⅞ x 5 at $0.635/sq ft = $0.065

Set-Up	Run Time	Operation
12.00	0.050	Shear to Length
12.00	0.087	Shear to Width
	0.290	Layout and Scribe
5.00	0.200	Saw off Flange
10.50	0.034	Bend to 22° Angle
	0.150	Check by Operator
39.50	0.811	Total Minutes

Flange—(3) Material 0.091 x ⅜ x 5¾ at $0.635/sq ft = $0.015

Set-Up	Run Time	Operation
12.00	0.050	Shear to Length
12.00	0.087	Shear to Width
30.00	0.087	Shear to Angle
	0.150	Check by Operator
54.00	0.374	Total Minutes

Boss—(4) Material ⅞ Dia x 5/32 at $0.34/ft. = $0.005

Set-Up	Run Time	Operation
28.40	0.735	Cut to Length on Turret Lathe
28.40	0.735	Total Minutes

Summary of Detail Parts

Part Name	Part No.	Set-Up	Time Run	Material	Tools
Web	—1	17.00	3.460	0.091	—
Flange	—2	39.50	0.811	0.065	—
Flange	—3	54.00	0.374	0.015	—
Boss	—4	28.40	0.735	0.005	—
Total Minutes		138.90	5.380	0.176	
Total Hours		2.32	0.089		

Welded Fitting Assembly

Assembly and Weld Fixture = $30.89
Prick Punch Template = $19.30

Set-Up	Run Time	Operation
5.00	4.500	Assemble in Fixture & Tack Weld
	4.572	Arc Weld
	2.494	Heat Treat and Straighten
5.00	0.450	Spot Face Boss
10.00	1.818	Drill and Ream Boss
2.00	0.631	Drill 7 Holes
	0.200	Burr Holes
	0.150	Check by Operator
	0.474	Stamp Part No.
	3.000	Finish
22.00	18.289	Total Minutes
0.366	0.304	Total Hours

Summary

	Set-Up	Run Time	Material	Tools
Detail Parts	2.320	0.089	0.176	—
Welded Assem.	0.366	0.304	—	50.19
Total	2.686	0.393	$0.176	$50.19

Unit Set-Up Cost = $\frac{2.686 \times 7.02}{25} = 0.75$

Unit Run Time Cost = $0.393 \times 7.02 = 2.76$

Unit Mat'l Cost = $0.176 \times 1.05 = 0.18$

Unit Tool Cost = $\frac{50.19}{100} = 0.50$

Total Unit Cost $4.19

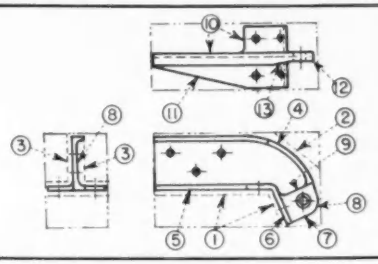
Fig. 4—Breakdown of costs of material, fixed tools, setup, labor, dies and patterns to

At the time the analysis is evaluated, for example, tool information is coordinated with tool representatives to obtain comments and suggestions relative to tool economy. Approval signatures are seldom demanded because the final design decision is the prerogative of the design engineer. When a cost design decision is made the designer informs the tool project representative, who in turn transfers the necessary data to the tool planning group. Complete tool coordination is thus achieved with the minimum of paper work. Information from the other departments is similarly coordinated and accumulated for cost evaluations.

This procedure aids the cost engineer in decreasing the preparation time of analyses for prompt cost decision and directly reduces drafting schedule delays.

With the present method of issuing design cost bulletins, a high degree of cost conscious attitude has been obtained in engineering personnel. The purpose and usefulness of the three basic design bulletins in aiding the design engineers were discussed in "Designing With Dollars," Product Engineering, March 1948, p. 81, by the author.

MACHINED BAR STOCK — 24ST



24ST Al. Alloy Bar 2 x 2¼ x 5⅛ at $2.90/ft = $1.30

Set-Up	Run Time	Operation	
	5.00	0.138	Saw to Length	
	42.00	1.796	Square 2 Sides	4 Cutter
(1)		1.180	Rough Mill 1 11/16 Dim.	"
		40.000	Layout	
(2)		0.934	Rough Mill 2 5/16 Dim.	"
(3)	18.75	4.247	R. Mill Pocket (both sides) and ⅛ Flg.	1⅛ Cutter
(4)		1.152	Finish Mill 1 11/16 Dim. (1-Side)	"
(5)		1.152	Finish Mill 1 11/16 Dim. (other side)	"
(6)		0.965	Finish Mill 22° Angle	"
(7)		0.990	Finish Mill ⅞ Dim. at Boss	"
(8)	48.75	2.146	Finish Mill Pocket and 7/16 R. (Rotary Table)	½ E. Mill
(9)		1.177	Finish Mill Inside ⅞ Dim.	"
(10)		1.125	Mill 2 15/16 Dim. (Cut Off Flg.)	⅛ "
(11)		1.109	Mill Taper—Lower Flg.	"
(12)		1.050	Mill Boss .255/.245	"
(13)		0.978	Mill Taper—Upper Flg.	"
		1.553	Check by Operator	
	10.00	1.794	Drill & Ream Boss (Use P.P. Temp.)	
	1.00	0.599	Drill 7 Pilot Holes	
		6.080	Break Sharp Edges and Burr Holes	
		0.474	Stamp Part No.	
		5.000	Finish	
	125.50	75.639	Total in Minutes	
	2.09	1.261	Total in Hours	

Prick Punch Template 5 Hrs. x 3.51 = $17.55
Template Mat'l = 10% of 17.55 = 1.76
Total Cost of Template $19.31

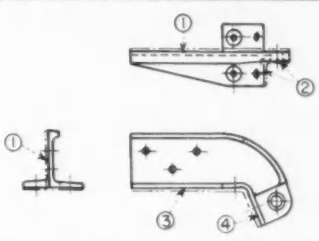
$$\text{Unit S/U Cost} = \frac{2.09 \times 7.02}{25} = \$0.59$$

Unit R/T Cost = 1.261 x 7.02 = 8.85
Unit Mat'l Cost = 1.30 x 1.05 = 1.36

$$\text{Unit Tool Cost} = \frac{19.31}{100} = 0.19$$

Total Unit Cost = $10.99

MACHINED FORGING — 24ST



Set-Up	Run Time	Operation
(1) 42.00	2.067	Mill Face
(2)	0.965	Mill Opposite Face (at Boss)
(3) 18.75	1.180	Mill Lower Flange
(4)	0.965	Mill 22° Angle Face
	0.832	Check by Operator
10.00	1.794	Drill and Ream Boss
2.00	0.599	Drill 7 Pilot Holes
1.00	1.089	Spot face 2 Holes
	4.080	Break Edges and Burr
	5.000	Finish
73.75	18.571	Total Minutes
1.23	0.31	Total Hours

Prick Punch Template $19.31
Forging Die $675.00
Die Set-Up 5% 33.75
Forging 0.58

$$\text{Unit S/U Cost} = \frac{1.23 \times 7.02}{25} = \$0.35$$

Unit R/T Cost = 0.31 x 7.02 = 2.18

$$\text{Unit Tool Cost} = \frac{19.31}{100} = 0.19$$

Unit Forging Cost = 0.58

$$\text{Unit Forging Die and Die Set-Up Cost} = \frac{708.76}{100} = 7.09$$

Total Unit Cost = $10.39

MACHINED CASTING CLASS "A"

Set-Up	Run Time	Operation
42.00	2.067	Mill Face
	0.965	Mill Opposite Face (at Boss)
18.75	1.180	Mill Lower Flange
	0.965	Mill 22° Angle Face
	0.832	Check by Operator
10.00	1.794	Drill and Ream Boss
2.00	0.599	Drill 7 Pilot Holes
1.00	1.089	Spot Face 2 Holes
	4.080	Break edges and Burr
	5.000	Finish
73.75	18.571	Total Minutes
1.25	0.31	Total Hours

Prick Punch Template = $19.31

Pattern = $48.00
Casting = 0.30
Testing = 442.40

Unit S/U Cost = 0.35
Unit R/T Cost = 2.18
Unit Tool Cost = 0.19

$$\text{Unit Pattern Cost} = \frac{48.00}{100} = 0.48$$

Unit Casting Cost = 0.30

$$\text{Unit Testing Cost} = \frac{442.40}{100} = 4.42$$

Total Unit Cost = $7.92

fabricate fitting by each of four methods. The time value for each operation is evaluated from cost control standard data books.

In the bulletin "Comparative Costs of Materials" are cost data on all metallic materials used in the fabrication of parts. The data covered stock, sheet stock, tubing, extrusions, castings and forgings, in all commonly used alloys of aluminum, steel and magnesium. Figs. 5, 6, and 7 are sample pages of this bulletin.

After a satisfactory functional design has been established and the amount of material needed to manufacture it has been determined, the designer refers to the material cost tables and charts to select the most economical material. Depending on his judgment of the design factors, he can specify a forging at a dollar a pound or a sheet metal fabricated design at fifty cents a pound.

In the bulletin, "Comparative Costs of Standard Parts" are listed cost of standard parts such as rivets, bolts, screws and studs. Usually the installed cost rather than initial cost of a standard part determines whether it can be used or not. Installed cost of standard parts used in general applications, therefore, is organized into two main divisions: (1) Structural designs, and (2) non-structural designs. With this data the designer is able to select the most economical standard that meets design requirements.

Where many types of bolts can be used to connect the fitting to a structural member, the designer has data on several types of standard bolts at his finger tips. The designer's selection sets the cost of installation for the fitting. Knowing the cost, strength and weight of the selected standard part, he can discuss his selection with the stress and weight engineers for further confirmation.

The bulletin "Design for Economy" contains information that is most difficult to correlate from the standpoint

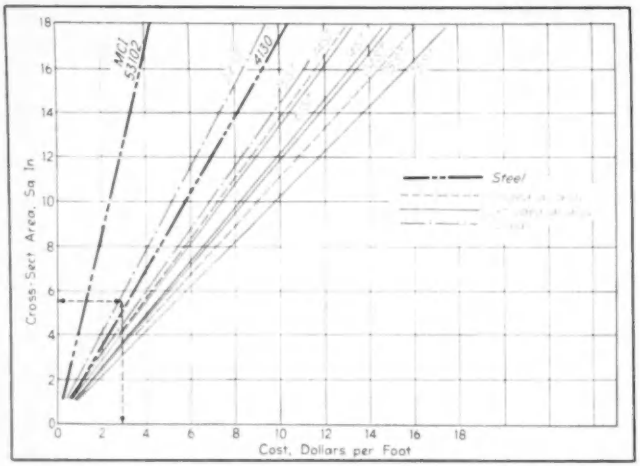


Fig. 5—Comparative cost of aircraft bar stock, for 100 to 300 lb in random lengths.

of the cost control group. The object of the bulletin is to imbue the designer with a sense of design perspective.

Although cost data given in the first two bulletins are easy to use, they can be considered only as a supplemental aid to the designer. But the art of design cannot be reduced to rules. It derives from the designer's experience and from the degree of intelligence with which he applies his knowledge to current problems and situations.

The third bulletin, therefore, avoids a too-detailed treatment of design details. The first part is a design check list of questions that a design checker might ask in reviewing a drawing.

The second part of the bulletin discusses several production factors such as: Simplification, practicability of assemblies and installations, limits and clearances, and use of existing parts and standards. The remainder of the bulletin is a comparative cost analysis of classified aircraft fittings. The data are given in cost summary sheets; Fig. 3 is a typical example.

As a series of historical references of fitting designs, these summary sheets are of great value to the designer. Using these references for comparing similar shape, size and weight to a newly designed fitting, will enable the designer to make a design decision with a fair degree of accuracy.

The procedure followed in obtaining the data itemized in Fig. 3 is typical of how design cost control operates in arriving at a design decision. Four methods of fabricating the fitting were analyzed to determine the most economical method of manufacture: (1) 24ST machine bar stock, (2) 24ST machine forging, (3) 4130 welded steel, and (4) machined aluminum alloy casting.

Premise is set for 100 parts, with releases set at 25 parts. This premise, as in any cost study, is of vital importance since the quantity of parts to be made has a direct bearing on the method of manufacture.

In Fig. 4 is shown the breakdown of costs of material, fixed tools, setup, labor, dies and patterns to fabricate the fitting by each of the four methods being studied.

The first step in the analysis is to develop material costs.

Material cost of 24ST bar stock needed to make the fitting is found by calculating the square inches of cross-sectional area of stock required, and reading the cost dollars per foot from Fig. 5 and multiplying this cost by the number of feet needed per fitting.

Material cost of an aluminum alloy forging to make the fitting is found by considering the type and shape of the forging, estimating its weight and then reading the cost-dollars per forging from Fig. 6. Using the same weight basis, the cost of the forging die is read from Fig. 7. The forging set-up cost is taken at about 5 percent of the die cost.

Material cost for the welded steel fitting is developed in like manner with the aid of a comparative cost chart, which gives the cost per square foot of sheet metal stock of different thicknesses.

In like manner, after considering the type, shape and weight of the cast fitting, its material cost, and pattern cost are read from charts in the bulletin "Comparative Costs of Material."

The next step in the analysis is to develop the manufacturing cost by means of an elemental breakdown of set-up and labor time in machining or fabricating each design, Fig. 4. To develop these elemental breakdowns requires an experienced man who knows all types of machines in the shop as well as the techniques used in producing a part from these machines. The design cost control engineer on the floor has at his fingertips the knowledge and techniques to analyze these fittings as to their elemental breakdown.

The time value for each operation is evaluated from standard data books compiled by the cost control group.

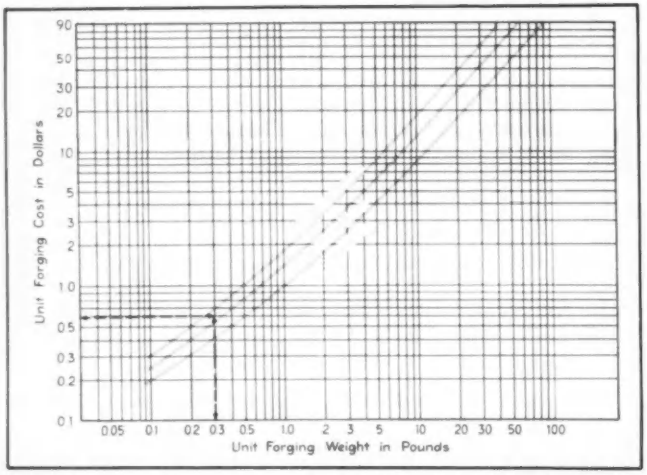


Fig. 6—Unit cost of aluminum alloy forgings, based on a premise of 100 pieces.

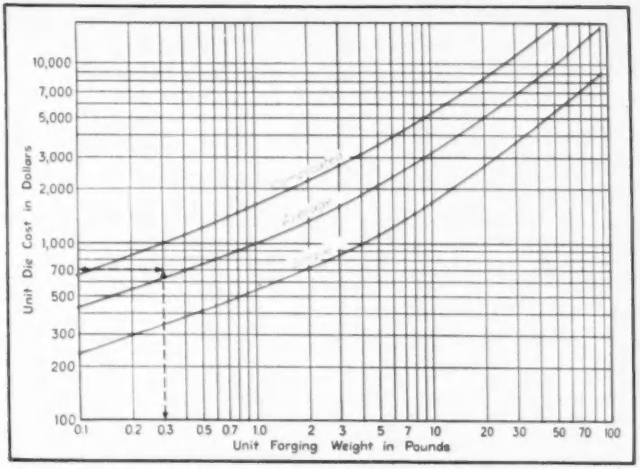


Fig. 7—Unit cost of forging dies for three classifications of aluminum alloy forgings.

Standard data is a time value developed from a series of time studies of each individual motion that a man or machine performs in fabricating a product. These time study values are correlated, summarized and modified with variables into a unit standard value for specific operations. Since each time value is an average, its application to shop operations must be applied with sound judgment to achieve correct values for each elemental operation.

Adding the elemental time values for both set-up and run time establishes the total operation time sequence for each type of fitting. Normally this total in minutes is changed to hour values for conversion to dollar costs.

The evaluation of the dollar cost conversion factor requires the incorporation of cost accounting data for rework and rejection allowances, workers fatigue allowances, direct labor immediate supervision adjustment factor, and average departmental efficiency percentage. The application of these percentage factors to the unit standard data time value develops into the actual performance factor.

Then by applying the average direct labor rate and burden percentage, the complete dollar hour conversion factor is evolved. This figure when multiplied with the amortized set-up and multiplied directly with the run time standard hour time will give the final dollar cost of fabrication.

After the material and fabrication cost of each fitting has been determined the next step is the consideration of the tooling cost to complete the total manufacturing cost.

Tooling has an important effect in the cost of manufacturing a product. Where production quantities are small, the unit tooling cost can be a major portion of the product cost. Tooling cost alone at times can be the deciding influence in making a design decision without going into a detail analysis of the fabrication cost. For large production quantities, however, the unit tooling cost is often a negligible amount of the total manufacturing cost because the tooling cost is directly amortized over many parts.

Turning back to the fitting analysis, Fig. 4, the tools necessary to complete the analysis are composed of a prick punch template for locating the attachment holes and a welding fixture. All four fitting designs require the prick punch template with only the welded design requiring the additional welding fixture. The type of tools and the manufacturing hours to build them are coordinated with the tool planning engineers. Applying the proper labor and burden rates to the manufacturing hours provides the total tooling cost for each tool.

One more cost item called "specification test", Fig. 3, must be applied to the manufacturing cost of the Class "A" Casting, since this casting is classified as a structural fitting. The testing cost is amortized over the quantities of purchased castings. This testing cost is composed of structural engineering and laboratory costs.

Combining the tooling, material, fabrication and testing cost gives a

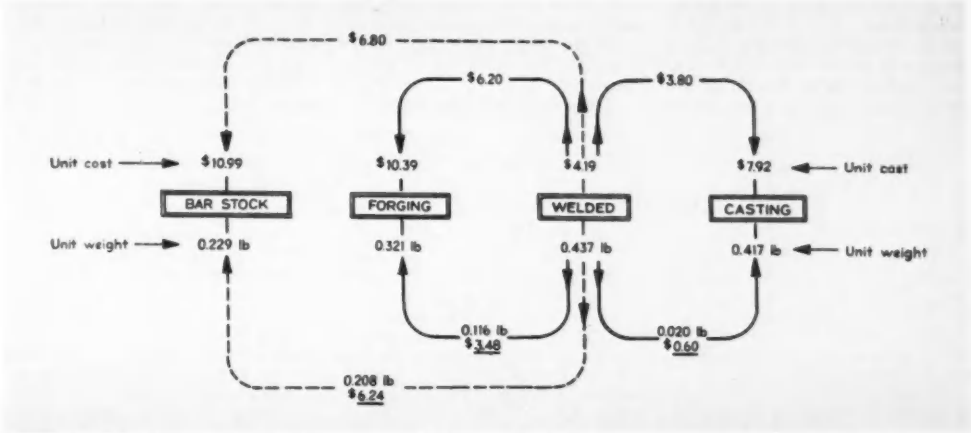


Fig. 8—Manufacturing cost versus weight evaluation of fittings made by four methods where the cost-weight ratio is critical.

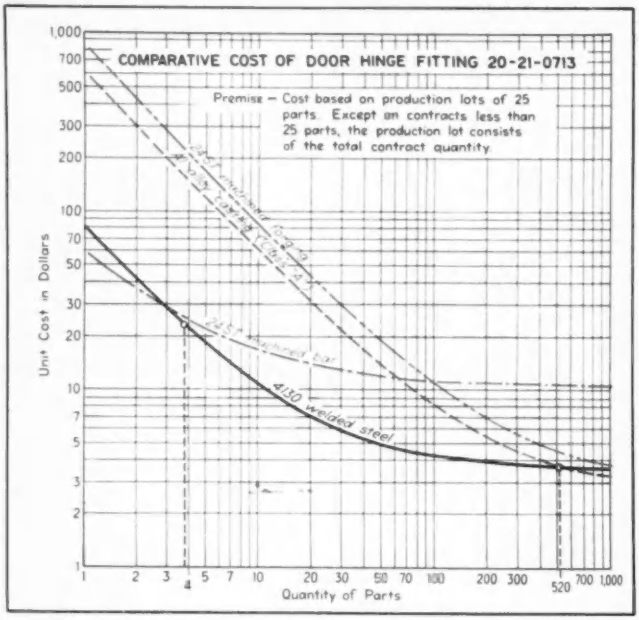


Fig. 9—Relation between quantity of fittings in a production lot and unit cost.

total unit manufacturing cost for each fitting; $10.99 bar stock; $10.39 forging, $4.19 welded and $7.92 casting.

From the cost standpoint, the analysis of each type of fabrication indicates that the welded fitting is the cheapest method, but this fitting also weighs the most. This factor brings up another very important point in all cost evaluations.

If weight is not critical on the particular model where this fitting will be used the cost alone can be the deciding factor. But if the weight is critical, the cost of manufacturing each fitting must be carefully compared to its respective weight. As can happen, the least costly fitting is not always the one that should be used. To control the decision of the cost-weight ratio, the engineering department has agreed to expend $30.00 of added manufacturing cost to save a pound of weight.

Using the fitting with the lowest manufacturing cost, Fig. 8, the additional cost to save weight can be computed in comparison with the other three designs.

1. The casting will save 0.02 lb; at $30.00 per lb of weight saved, this weight savings will cost 60 cents. Actually the weight saving cost $3.80. Therefore, the casting should not be considered.

2. The forging will save 0.116 lb at a value of $3.48, actual cost $6.20.

3. The bar stock will save 0.208 lb at a cost of $6.24, but will cost $6.80.

In exceptional designs where weight is extremely critical, consideration may be given to use this method of manufacturing.

The welded fitting is therefore basically the most economical from both cost and weight, as it does not exceed the value of $30.00 per lb of weight saved.

If the manufacturing cost were not considered, most designers would probably have picked the machined bar stock fitting because of its light weight. Thereby unknowingly increasing the cost of the product.

As emphasized in the early part of the fitting analysis, quantity of parts to be made has a direct bearing on the method of manufacturing. The importance of this statement is graphically portrayed in Fig. 9, which shows the quantity of parts against manufacturing cost. Notice that up to 4 parts the machined bar stock fitting is the recommended design; with the welded fitting the most economical design from 4 to 520 parts; beyond this number of parts the casting becomes the best method of manufacturing.

Noting that manufacturing cost varies with quantity of parts the difference in cost between any two methods will also vary, making it necessary for the cost control engineer to recalculate the cost per weight saved to determine the best design.

The cost control group by continually analyzing designs is developing a series of case histories covering all types of design problems. These histories can be a valuable asset to the designer as reference material to aid in making wise decisions on future model designs. Also, they stimulate the search for efficient low cost production methods. The application of design cost control techniques are thus developing designers with a new version of basic production thinking.

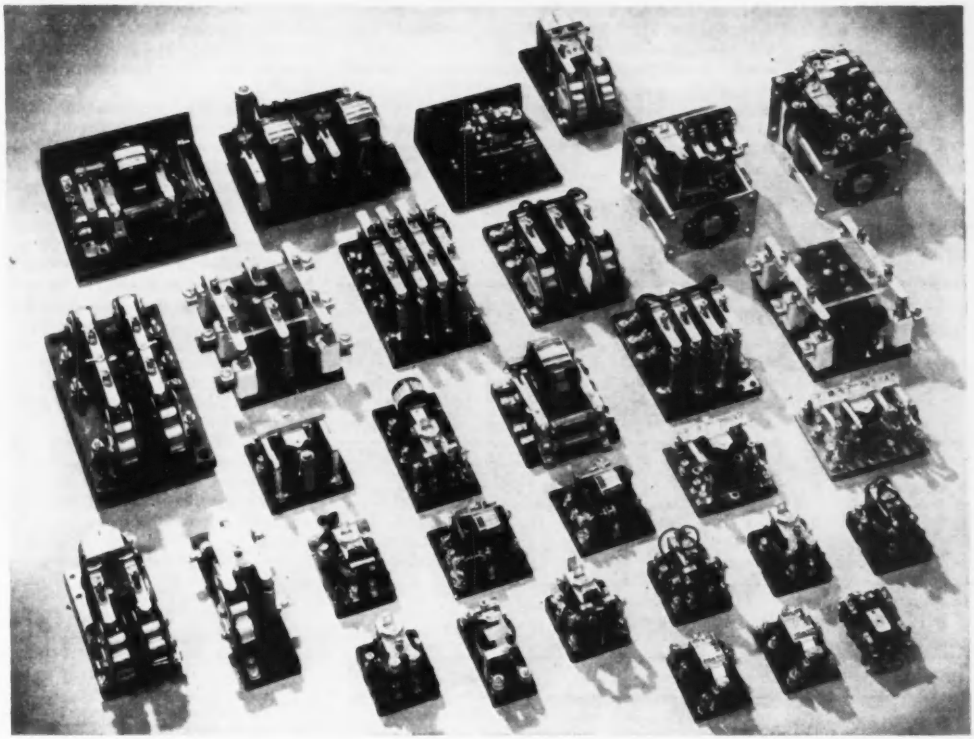
New Torque Converter Promises Economies

A DISTINCT DEPARTURE in fluid coupling design, the Fluid-Controlled Transmission, was unveiled in Cleveland recently. The design calls for less than thirty parts, including bearings and bushings and is expected to cost no more than the conventional manually-operated type.

The transmission is of new design in that the fluid coupling controls the changing of ratios of fixed gearing and constant mesh instead of driving the car. When the crankshaft is turning at 2,000 rpm, the transmission's pump is also at 2,000 rpm, but a turbine driven through a gear train revolves in the opposite direction at 1,200 rpm. Eventually as power is applied, the pump overrides the turbine and takes it along with it while the ratio gradually changes from the original 4.5 to 1 ratio to direct drive.

When the load is increased while climbing a hill, accelerating to pass a car, etc., the transmission, through exertion of added pressure against the pump and turbine, will immediately seek a lower ratio. This characteristic demonstrates the fact that no freeze-out principle is utilized.

The 35-lb prototype assembly was installed in a 1940 Ford pick-up truck as part of the flywheel. Being small and compact the unit can therefore be located at any point along the drive shaft of automotive equipment.



REPRESENTATIVE GROUP of magnetic control relays. Variations in dimensions, methods of mounting, circuit connections, contact materials, coils and other features are made to insure satisfactory operation under different operating conditions.

Selecting Magnetic Relays

For Industrial Controls

Nine factors governing the selection of industrial-type magnetic relays, and how each affects relay performance. First of two articles covering basic magnetic relay types and applications.

H. F. LITTLEJOHN, JR.
Application Engineer,
Ward Leonard Electric Company

LOW VOLTAGE MAGNETIC RELAYS can be used to perform many different types of control functions on industrial equipment. As with other mechanical and electrical components, however, maximum benefits are not obtained unless the designer considers the major factors governing the performance and operation before making a selection.

Insofar as magnetic relays for industrial control purposes are concerned, those factors are: (1) the operating voltage, and the current and power necessary to actuate the relay; (2) the contact ratings required; (3) the contact combinations available; (4) the operating speed; (5) the operating life cycle; (6) the method of mounting; (7) the type of enclosure necessary; (8) environmental conditions that will be encountered in service; and (9) initial cost.

Voltage, Current and Power

With few exceptions, industrial control magnetic relays are designed flexible enough so that they can be converted for use on either alternating or direct current. Certain variations in magnet and coil design are essential to satisfactory performance on each type.

For example, the magnets of a-c relays should be laminated for the ultimate in efficiency. By laminating the magnets, eddy currents and core losses are held to a minimum value, thus limiting heating and resulting in

Table I—Electrical Characteristics of Typical Magnetic Relays for Industrial Control

Relay		Approx. Size, cu in	Average Contact Ratings[1]				Max. Permissible Coil Voltage		Average Coil Power Consumption, watts	
			A-C 60 Cycle		D-C					
Classification	Type		Amps	Volts	Amps	Volts	A-C	D-C	A-C	D-C
Heavy duty	Single break	35–60	25 15	24 440	25 1	24 250	440	230	8	4
	Double break	35–60	30 20	24 440	30 2.5	24 250	440	230	8	4
Midget	Metal base or Phenolic base	6 8	4–6 4–6	24 125	4 1	24 125	230 230	115 115	4 4	2 2
	Heavy duty or Special purpose	8	10–20	125	10–20	24	230	115	4	2
Miniature	Metal base	1.5	2–3	115	2	32	115	32	1.3	1.5
Sensitive		8.5	2	24	2	24	115	115	33 VA	0.014
Capacitor motor starting (Special)		10					230	–	5	–
Latch-in	Heavy duty	40–70 See heavy duty					440	230	8 main 4 reset	
	Midget	15 See midget					250	115	4 main 4 reset	

[1]Non-inductive—single break unless otherwise indicated.

more efficient operation. Considerations other than efficiency, however, often necessitate a compromise in design, particularly in the smaller types of relays where it may be too costly or otherwise impractical to use laminated structures. In such cases, other means such as slotting of cores and frames must be used to keep losses at a minimum. To reduce chatter and minimize hum or noise when an a-c relay is in the energized position, "lag loops" or shading coils are used. These "lag loops" surround a section of the pole faces of the core or armature and usually serve a secondary function of holding the operating coil in place.

Magnet frames for d-c relays may be of solid iron construction. No lag loops are required since the coil current is uni-directional. However, a thin strip of non-magnetic material usually is inserted in the pole face of the core to provide a slight air gap between the armature and the core when the armature is sealed, thus minimizing the effects of residual magnetism, which may cause improper or sluggish armature drop-out. Unlike a-c relays in which the heating of the operating coil is due largely to core and frame losses, heating in d-c relays results directly from losses in the coil winding, since the coils have a relatively large number of turns of fine wire and high ohmic resistance.

Coils can be manufactured for operation on any voltage and frequency, but in general they have been standardized for service on 6, 8, 10, 12, 24, 32, 48, 60, 115 and 230 a-c or d-c, and 440 volts a-c. For standard control applications, a-c magnetic relays are designed to pick-up at 85 percent of nominal voltage or less, and drop-out at a sufficienly high voltage to prevent "hold in" or residual magnetism. Those for d-c application usually pick-up at 75 to 80 percent, with the same precautions taken on drop-out. On some standard designs, these points are preset and are non-adjustable, while on others provision is made for adjustment in the field, as is the case with the midget relay shown in Fig. 1.

On a-c relays, the initial or inrush coil currents are usually several times greater than nominal currents. The amount of current drawn by the coil depends mainly on the reactance of the circuit, which is lower when there is a large air gap in the magnetic circuit. As the relay armature closes, the reactance of the circuit increases and lowers the coil current until the armature is sealed, whereupon the coil carries normal current. Since the current drawn by the coil depends on the coil resistance in d-c applications, coil current is independent of armature position.

The voltage of the circuit may have a direct bearing on the type of relay selected, i.e., heavy duty, midget, miniature, or others. For instance, a midget relay might be desirable due to space limitations, but if the circuit voltage is in excess of rated voltage, the relay manufacturer should be consulted before selection is made. Some small relays are designed specifically for low voltage applications and do not have sufficient insulation resistance or clearances for operation on higher voltages. In some circuits a voltage dropping resistor can be connected in series with the relay coil, thus lowering the voltage applied directly to the coil. This means, however, is not corrective and does not lessen hazards to ground. In others, where a-c relays are involved, a control transformer can be used for reducing voltage.

Contact Ratings

Most magnetic relays are designed so that the contacts or switch points can carry either alternating or direct current independent of the operating coil voltage. Contacts are usually made of fine silver, but such materials as platinum, palladium, molydenum, copper, graphite or carbon impregnated metals, and various metal alloys also are used for special purpose control applications. On elevator and other control panels where safety is of primary importance, graphite-impregnated or pure carbon contacts are often furnished to avoid contact welding or sticking during operation.

Relay contact ratings depend on nu-

Fig. 1—Midget relay with provision for adjustment of pick-up and drop-out voltages; these points usually are pre-set.

merous factors such as contact material, contact pressure, contact gap, and type of load. The ratings assigned relay contacts by most manufacturers represent the normal amount of current that the contacts can carry continuously, or that they can make and break repeatedly at a specified voltage and frequency. For purposes of uniformity and simplification, the ratings given are for non-inductive loads other than lamp loads.

When inductive loads are encountered, the assigned non-inductive ratings must be reduced. Failure to do so will decrease contact life and may prevent the relay from making and breaking the circuit effectively. The contact derating required for any application is best determined by actual test, but the manufacturer can usually approximate the rating.

For heavy duty service with inductive loads, d-c control relays are equipped with magnetic blowouts, in which case the relay contact ratings may be extended to approach the a-c ratings. The function of these devices is to extend or stretch out the resulting arc formed on breaking the load circuit and thus to increase the current interruption capacity of the contacts and minimize contact wear. On the relay shown in Fig. 2 for a reversing d-c motor, a magnetic blowout is incorporated to extinguish the arc after each reversal.

One type of magnetic blowout consists basically of a small coil that is connected in series with the stationary contact; the amount of current passing through the contacts determines the number of turns and wire size. The exact continuous or normal current that the contacts will carry should be specified for relays requiring magnetic blowouts. Also, it should be remembered that excessive currents will overheat the blowouts, while low currents will often make them ineffective since they will not develop sufficient magnetic flux to readily extinguish the arc.

Although utilized primarily on d-c relays where the arcing current is unidirectional, magnetic blowouts also can be used satisfactorily on a-c. Their limited use on a-c may be explained by the fact that when an a-c circuit is interrupted, the arcing current travels through zero, reversing polarity twice each cycle; this current reversal tends to extinguish the arc automatically.

Permanent magnet blowouts are sometimes used in lieu of magnetic coil type blowouts. However, extreme caution should be exercised with these devices to avoid polarity reversal during installation. If the circuit polarity is reversed, the arc is blown in the opposite direction from that desired and the relay may be damaged. For this reason, permanent magnet blowouts are not recommended for d-c control circuit applications unless their use is dictated by other considerations, such as varying loads.

Circuit Combinations

When the operating coil of a magnetic relay is de-energized, the relay contacts are considered in their "normal position." In this position, the contacts may be either normally open or normally closed. The number of poles, type of break, and type of throw all have an important bearing on relay selection. Some industrial control relays are limited to single or double-pole combinations, while others can accommodate as many as six or eight separate poles. On several types, single or double-break contacts can be specified as standard.

SINGLE-BREAK CONTACTS, as their name implies, can open and close a circuit in one location only. On single-break, multi-pole magnetic relays, the contacts normally make or break the circuits simultaneously. However the contacts can be made adjustable to permit setting one pole higher or lower so its contacts make or break slightly before or after the other poles.

DOUBLE-BREAK CONTACTS make or interrupt the circuit in two places simultaneously. They are usually rated higher than those of the single-break type, as indicated in Table I. Although double-break contacts are suited to both high and low voltage circuits, they are particularly advantageous for high voltage d-c applications. With them, "pigtails" or flexible jumpers required on single-break contacts for making connection to the movable contact fingers are not needed, and for this reason, the wearing qualities of double-break contacts may be better.

A SINGLE-THROW RELAY has its contacts arranged so that each pole performs a single function. The contacts, which are either normally open or normally closed, function to close the circuit or open the circuit when the coil is energized.

A DOUBLE-THROW RELAY performs two functions, that is, it has one set of normally open contacts and one set of normally closed contacts for each pole. These contacts may be isolated or non-isolated depending on the construction of the relay. On those with isolated contacts, each set of contacts is mechanically and electrically independent of the other; the relay shown in Fig. 3 is typical of this construction. With non-isolated contacts,

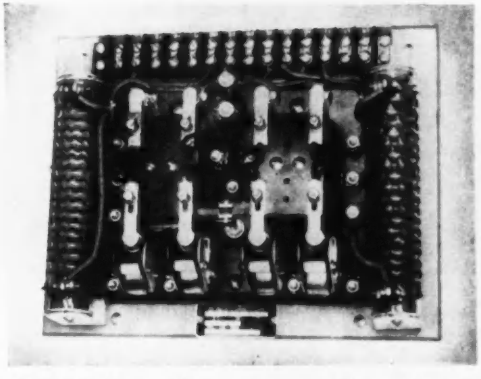


Fig. 2—Special reversing motor starter with provisions for dynamic braking. Carbon to silver contacts and magnetic blowouts are used for the directional relays.

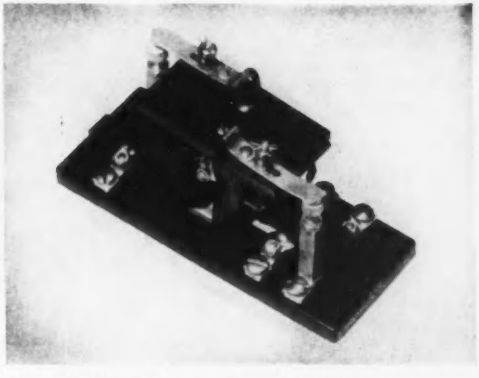


Fig. 3—Double throw heavy duty relay with isolated contacts—i.e. each set of contacts being independent of the other. Such units also can be obtained with non-isolated contacts.

there is only one movable contact finger per pole, and it is common to both sets of contacts.

A DOUBLE-THROW TRANSFER RELAY has its contacts arranged so that each pole performs a dual purpose. It allows transfer by means of a common feed from one circuit (normally closed contact) to another circuit (normally open contact).

For applications where a common source of supply feeds two separate load circuits, a single-pole, double-break relay can be used as a double-pole relay, provided a common feed lead is added. With this contact arrangement, the ratings must be reduced to correspond with those for single-break contacts.

Operating Speed

The operating speed of magnetic relays, exclusive of timing relays, is inherently fast. The average closing speed of a typical a-c heavy duty relay is 1-½ to 3 cycles, or 25 to 50 milliseconds on 60 cycle current, which is considerably faster than the operation of most control devices with which it may be used.

The operating speed is determined essentially by the rate of flux build-up combined with the armature closing time. Usually d-c relays are slower in operation than a-c relays. Without using a special magnet frame or core, relay operating speed can be changed by varying the spring tension, the armature-core air gap, and the coil inductance.

Enclosures

In most built-in relay applications, the controller enclosure generally provides adequate protection for the relay, but when relays must be installed remote from the controller or equipment, a separate enclosure should be selected. One popular relay enclosure used for general purpose applications indoors consists of a steel knockout box with a hinge or slip-on type cover. This enclosure gives adequate protection against accidental contact, mechanical damage, and light indirect splashing.

For other indoor applications where the atmosphere is laden with dust or foreign particles or is excessively moist, an enclosure consisting of a glass cover with a cast metal or bakelite base is generally satisfactory. Designed for front-of-board mounting, these metal base enclosures are tapped for several ½-in. pipe connections. Those with insulating bases are intended for switchboard mounting when the relays have back-connected terminals.

If relays must be located outdoors, cast or sheet metal enclosures that are weather resistant or watertight are recommended, as shown in Fig. 4. Other enclosures, such as those for hazardous locations, must be designed to meet specific application requirements. Sometimes special enclosures can be eliminated by avoiding separate mounting or by installing the relay outside the hazardous location.

Methods of Mounting

There are several different ways of mounting magnetic relays. The conventional means is front-of-board or panel mounting, in which case the relay base is bolted directly to a metal or insulating control panel. With this arrangement, the coil and contact wiring is made to front-connected screw or stud type terminals, or with some types of midget relays, to solder type terminals. For control panels with back-of-board wiring such as switchboards, magnetic relays can be obtained with back connected studs. In one type, studs are factory assembled as an integral part of the relay; in another, the studs can be wired prior to mounting; this permits easy replacement since the wiring need not be disturbed. A third form is identical with the first except that insulated sleeving is provided for the studs where they pass through the metal panel.

Relays that must be readily removed to facilitate quick replacement and periodic testing can be supplied with pin-plug connectors, Fig. 5. These relays can be plugged into or removed from receptacles installed in the panel board. This method of mounting allows completion of panel board wiring before relays are installed and eliminates the need for disturbing the wiring when the relays are removed.

A variation of pin-plug mounting is obtained by means of plug-in relays that are mounted on a standard octal base. Since relay terminals and socket terminals are insulated from the base, plug-in relays can be used on both insulating or metal control panels. These and other constructional variations for magnetic relays are shown in Table II.

Operating Life Cycle

The life expectancy of a standard industrial control relay may be estimated conservatively at one million operations. This does not infer that all relays will function satisfactorily without parts replacement for that number of cycles. Some relays have been known to exceed this number by 5 to 10 times, while the expected life of others of similar design and quality is considerably less. It is only through correct application and proper care

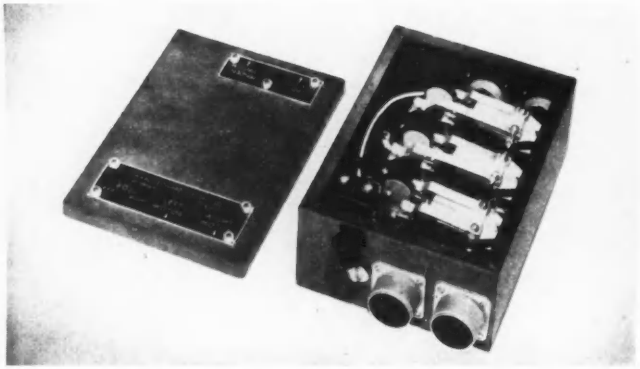


Fig. 4—Relay panel having a sheet steel, weather resistant enclosure (cover gasket not shown). This unit is a special type used for portable hoists. Other enclosures, such as those for hazardous locations, must be designed to meet application requirements.

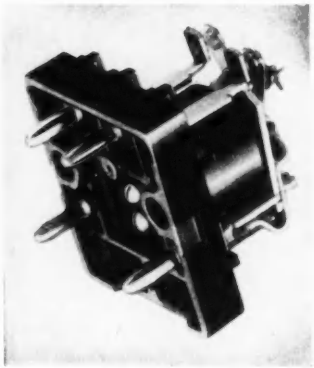


Fig. 5—Midget relay with pin plug connectors. Such a unit can be removed without disturbing the wiring.

of the relay after it is installed that the nominal life operating cycle can be achieved.

Several conditions may contribute to premature relay failure. A common cause is overloading, that is, placing an excessive load, continuously or intermittently, on the relay contacts; or placing excessively high voltage on the relay coil. Another is improper adjustment of the contact gap, lead or spring pressure. A third cause of failure is over-maintenance, which means excessive filing or oiling of contacts. Conversely, inadequate maintenance or periodic inspection, including failure to keep relays free from foreign substances—dirt, grease, or metal particles—often causes trouble. Still another reason for decreased life is unusual environmental conditions.

Unusual Service Conditions

Some of the unusual service conditions to which relays may be subjected are: (1) abnormal temperatures; (2) mechanical shock and vibration; (3) excessive humidity, salt spray, corrosive fumes, or fungus.

Since the environmental conditions vary so widely in different relay applications, no recommendations can be made that will apply in all cases. However, it is important that the designer recognize some of these unusual service conditions, so proper precautions can be taken when relays are specified.

As a protection against adverse atmospheric conditions likely to be encountered in service, it is almost imperative that magnetic relay coils be vacuum impregnated. Dipping or otherwise coating with insulating material will only protect against possible mechanical damage during assembly, shipment or installation. Thorough vacuum impregnation and the often overlooked end sealing of relay coils is important if long life is expected. Quality relays will have these features as a matter of course.

Most magnetic relays built for industrial controls will operate in ambient temperatures from sub-zero to 50 C without special precautions. The safe operating temperature range depends largely on the insulating materials used and, of course, temperature rise limitations. Some insulating materials become exceedingly brittle at low ambient temperatures, while others deteriorate rapidly at elevated temperatures. Extreme temperature deviation from normal affects relay insulation resistance, which, if substantially lowered, may result in failures. Excessively high ambient temperatures increase the temperature of coils and contacts, and parts may be permanently damaged. On close differential and sensitive relays, high ambient temperatures may alter pick-up and drop-out settings.

Where relays are to be installed on portable or mobile equipment, their ability to withstand mechanical shock and vibration should be considered. Some relays are inherently more resistant to these conditions than others. Those relays with lightweight or balanced armatures are generally more shock resistant than those of heavier unbalanced armature construction.

Where such adverse operating conditions as excessive humidity, salt-spray, corrosive fumes or fungus are encountered, special finishes are sometimes required on all parts. A second means of combating these conditions is through the use of protective enclosures, but if enclosures are employed, coil and contact temperature rise should be analyzed to avoid excessive temperature rise and overheating. Another way to protect against these conditions is by using hermetically sealed units.

Table II—Constructional Features of Standard Magnetic Relays for Industrial Controls

Construction Features	A-C Relays	D-C Relays
Coils	Usually layer wound coils with low ohmic resistance and relatively few turns.	Coils have high ohmic resistance and large number of turns.
Standard operating voltages	6, 8, 10, 12, 24, 32, 48, 60, 115, 230 and 440	6, 8, 10, 12, 24, 32, 48, 60, 115, and 230
Standard frequencies	50–60 cycles	
Pick-up voltages	Usually 85 percent of nominal	Usually 75 to 80 percent of nominal
Operating speeds	1½ to 3 cycles (25 to 50 milliseconds)	Slightly slower
Magnetic blowouts	Generally not required	Magnetic coil "blowouts" used to increase contact rating. Permanent magnet blowouts some times used for wide range of d-c loads.

Construction Features	A-C and D-C Relays
Contact materials	Contacts usually silver. Also platinum, palladium, molybdenum, copper, and carbon or graphite impregnated in special cases.
Number of poles	Some limited to single or double-pole combinations. Others have six to eight poles or more.
Type of contacts	Either single or double-break, some with adjustable contacts.
Type of throw	Single-throw, double-throw, or double-throw transfer type.
Enclosures	Open; steel knockout box with hinged or slip-on cover; light plastic or metal covers; glass cover with cast metal or bakelite base; sealed metal container.
Terminal connections	Usually screw or stud-type terminals. Sometimes pin-plug or plug-in connectors. Solder type terminals only on small midget or miniature units.

Initial Cost

Initial cost is always an important factor regardless of the component or device involved. However, in the case of relays, cost often occupies a secondary position simply because it is almost always low compared with the value of the entire machine or equipment on which the relay is to be placed.

While the best relays are not necessarily those that are lowest in cost, high cost does not always infer good quality and reliability, although it is often relied on with some degree of accuracy. A properly designed relay, correctly selected for a specific application, is invariably the wisest choice. The cost of one service call, plus idle machine time lost will more than offset any saving that might be made in first cost.

Accurate Calculation Of Static Bending Strength

The theory of limit design, which considers yielding of the material, determines the static strength of flexural members more accurately than standard stress analysis procedures. Application is made to members subject to both axial load and bending moment, namely hooks, shackles and rings, under static loads.

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THE ASSUMPTION that stress is proportional to strain is the foundation on which conventional stress analysis methods are built. However, static failure of a part is almost invariably preceded by such extensive yielding of the material that using this assumption gives overconservative values. To supply accurate information on static strength, a stress analysis method taking yielding into account was developed. This method is called the theory of limit design. It is used to calculate the external loads that would be in equilibrium with stresses equal to the yield point throughout the critical section. Such a stress distribution, when existing in a part, destroys the usefulness of that part. For this reason, the external loads calculated by the theory of limit design agree closely with the external loads which actually produce damage.

The difference between the theory of limit design and conventional stress analysis methods is shown in Fig. 1. In conventional stress analysis methods the stress is usually assumed proportional to the distance from the neutral axis, as shown in Fig. 1(*a*). This stress distribution exists until yielding of the material changes it to that shown in Fig. 1(*b*). Part of the cross-section is then stressed elastically and the remainder yields. Further bending would require increased stresses in the elastically loaded part of the cross-section and hence would require an increased bending moment. Therefore, as long as any part of the cross-section is elastically stressed, the amount of deflection possible with a given bending moment is definite. Conversely, when the entire cross section is stressed to the yield point, as shown in Fig. 1(*c*), an increase in bending deflection may occur without an increase in the bending moment. Therefore, the amount of deflection possible with a given bending moment is no longer limited.

Under these conditions, flexural yielding will continue until one of two events takes place. First, bending distortion of the part may reduce the moment arm of the applied load. The bending moment then decreases until the bending stresses are in the elastic range. The amount of bending distortion possible with the reduced bending moment thus becomes limited. The second event, less likely to occur, is static failure.

Both these events, extreme bending distortion and static failure, destroy the engineering usefulness of the member. Therefore, the condition of loading leading to these events is known as the limit design condition and the applied load is known as the limit load.

The theory of limit design can be applied to cross-sections subject to both bending moment and axial load. Under limit design conditions, a combined bending and axial load produces the type of stress distribution shown in Fig. 1(*d*). A cross section thus loaded can be divided into two portions, as shown in Fig. 1(*e*). The first portion is the two shaded areas, and the second is the unshaded area. The stresses in the two shaded areas are associated with the bending moment. The bending moment existing under limit design conditions is obtained in the following manner. First the static moments about the neutral axis of both shaded areas are added

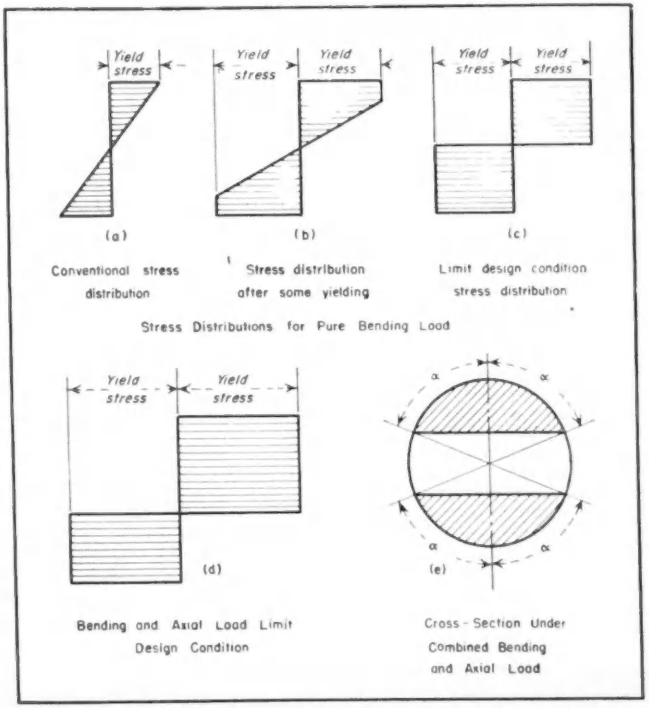


Fig. 1—Basic limit design principles and comparison with standard stress distribution.

together. The result is then multiplied by the yield stress to obtain the bending moment. The unshaded area is associated with axial force. Under limit design conditions the axial force equals this area times the yield stress.

Usually the relationship thus obtained between the bending moment and the axial force is not of a direct nature. The static moment of the shaded area and hence the bending moment is usually expressed in terms of some parameter, such as the angle α of Fig. 1(e). Then the unshaded area and hence the axial force are also expressed in terms of this same parameter. Since both the bending moment and the axial force are related to the same parameter, they are also related to each other.

Except for this way of relating axial force to bending moment, the theory of limit design is very similar to conventional stress analysis methods. The structural member is divided into free bodies through the critical cross sections. For these cross sections, the previously explained relationships between limit design condition bending moment and limit design condition axial force are set up. To these equations are added the equations of equilibrium of the free bodies obtained by the ordinary laws of statics. To get the limit load, solve all these equations simultaneously.

Sound appraisal of this method requires an understanding of both its proper field of application and its reliability in this field. It is not applicable where fluctuations in the applied load cause fatigue. It also is not applicable where fluctuations in the applied load substantially alter the yield point through work hardening. Under such conditions, brittle fracture might take place under loads less than the limit load as calculated on the basis of the initial yield point. Instead, the proper field of application of the theory of limit design is the stress analysis of flexural members subjected to loads primarily of a static character. To demonstrate the reliability of the theory of limit design in this field, the limit loads calculated for hooks, shackles, and rings will be compared to the actual static loads causing excessive distortion.

Analysis of Hook

The critical sections A-A and B-B of a hook subject to the external load P are shown in Fig. 2(a). The part of the hook between these sections is shown as a free body in Fig. 2(b). On each critical section the axial force P is applied. The distance between the lines of action of the axial forces on the critical sections is the hook radius R. The bending moments M_a and M_b are applied to sections A-A and B-B respectively. In Fig. 2(c) is shown section A-A, a circle of radius r_a. The shaded areas are associated with the bending moment. Under limit design conditions, the bending moment equals the arithmetical sum Q_{1a} of the static moments of these areas times the yield stress S. The unshaded area A_{2a} is associated with axial force. Under limit design conditions, the axial force equals this area times the yield stress. The bending moment and the axial force on section A-A are related to each other by expressing them both in terms of the angle α_a. In Fig. 2(d) is shown section B-B, an oval bounded by two semicircles of radius r_b connected by two tangent lines of length c. The bending moment is equal to the arithmetic sum Q_{1b} of the static moments of the shaded areas times the yield stress. The axial force equals the unshaded area times the yield stress. The relationship between the bending moment and the axial force is obtained by expressing them both in terms of the angle α_b.

The formulas for the required static moments and areas of the parts of sections A-A and B-B are:

$$Q_{1a} = \frac{4}{3} r_a^3 \sin^3 \alpha_a \tag{1}$$

$$A_{2a} = r_a^2 (\pi - 2\alpha_a + \sin 2\alpha_a) \tag{2}$$

$$Q_{1b} = \frac{4}{3} r_b^3 \sin^3 \alpha_b + r_b^2 c \sin^2 \alpha_b \tag{3}$$

$$A_{2b} = r_b^2 (\pi - 2\alpha_b + \sin 2\alpha_b) + 2 r_b c \cos \alpha_b \tag{4}$$

From these are obtained the equations:

$$M_a = S Q_{1a} = \left[\frac{4}{3} r_a^3 \sin^3 \alpha_a\right] S \tag{5}$$

$$P = S A_{2a} = [r_a^2 (\pi - 2\alpha_a + \sin 2\alpha_a)] S \tag{6}$$

$$M_b = S Q_{1b} = \left[\frac{4}{3} r_b^3 \sin^3 \alpha_b + r_b^2 c \sin^2 \alpha_b\right] S \tag{7}$$

$$P = S A_{2b} = r_b^2 [(\pi - 2\alpha_b + \sin 2\alpha_b) + 2 r_b c \cos \alpha_b] S \tag{8}$$

In addition, equilibrium of the free body requires that:

$$PR = M_a + M_b \tag{9}$$

Combining Eqs (6) and (8) and dividing both sides by S gives:

$$r_a^2 (\pi - 2\alpha_a + \sin 2\alpha_a) = r_b^2 (\pi - 2\alpha_b + \sin 2\alpha_b) + 2 r_b c \cos \alpha_b \tag{10}$$

Using Eqs (5), (6), and (7) to sub-

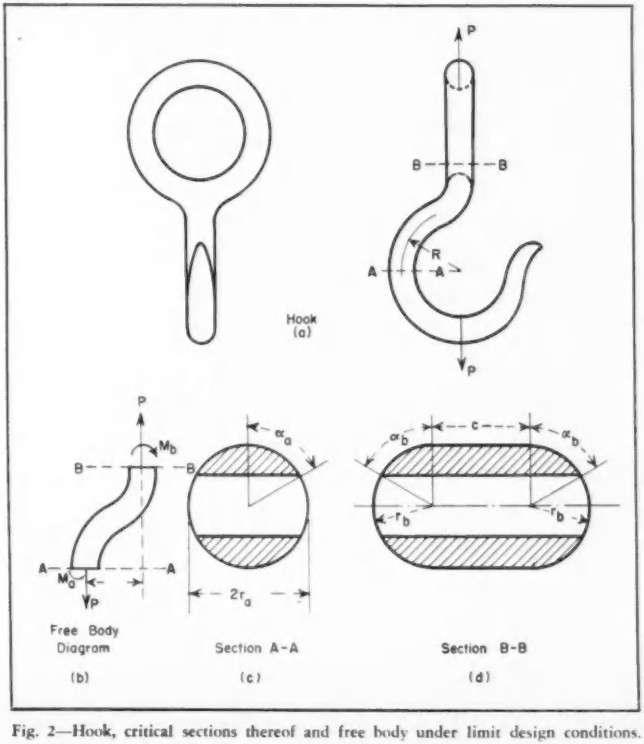


Fig. 2—Hook, critical sections thereof and free body under limit design conditions.

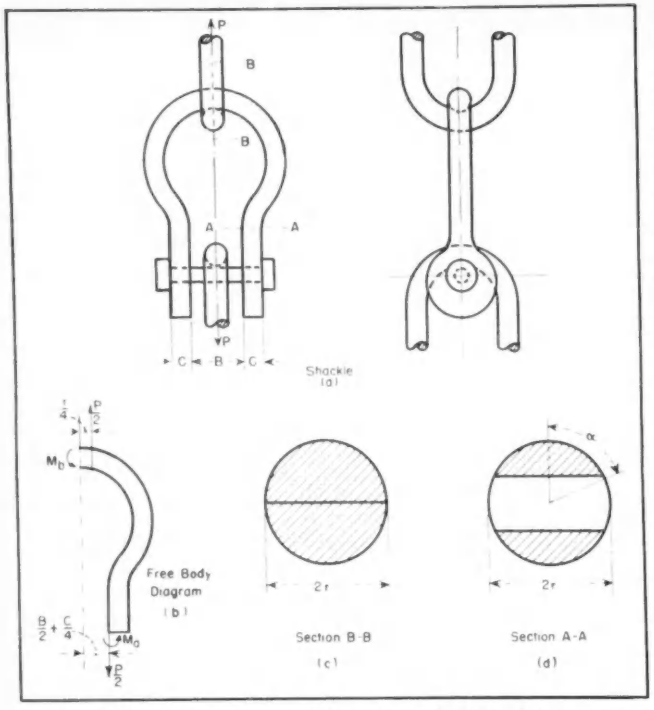


Fig. 3—Shackle, critical sections and free body under limit design conditions.

stitute for M_a P, and M_b in Eq (9) gives, after dividing both sides by S:

$$[r_a^2 (\pi - 2\alpha_a + \sin 2\alpha_a)] R = \left[\frac{4}{3} r_a^3 \sin^3 \alpha_a\right] + \left[\frac{4}{3} r_b^3 \sin^3 \alpha_b + r_b^2 c \sin^2 \alpha_b\right] \quad (11)$$

Equations (10) and (11) can be solved simultaneously for α_a and α_b by graphical methods. The values thus obtained can be substituted in Eqs (6) and (8) to obtain calculated values of the load P.

This method will now be applied to an example for which:

$R = 1.375$ in.
$r_a = 0.500$ in.
$r_b = 0.2815$ in.
$c = 0.4375$ in.
$S = 40{,}000$ psi

Substituting the given dimensions into Eq (10) and simplifying gives:

$$2\alpha_a - \sin 2\alpha_a = 2.1476 + 0.3164 (2\alpha_b - \sin 2\alpha_b) - 0.9844 \cos \alpha_b$$

Substituting the given dimensions into Eq (11) and simplifying gives:

$$1.0799 - 0.3438 (2\alpha_a - \sin 2\alpha_a) - 0.167 \sin^3 \alpha_a = 0.0297 \sin^3 \alpha_b + 0.0346 \sin^2 \alpha_b$$

Simultaneous solution of equations (10) and (11) gives:

$\alpha_a = 80.8$ deg
$\alpha_b = 73.3$ deg

Substitution of these values of α_a and α_b into Eqs (6) and (8) respectively gives values of P of 6,504 lb and 6,440 lb respectively. The slight discrepancy between these values is a result of rounding off errors. These values are in good agreement with the load for static failure of 6,610 lb determined by test.

Analysis of Shackle

In Fig. 3(*a*) are shown the locations of the critical sections of a shackle with the dimensions indicated subject to an external load P. The part of the shackle between two of these critical sections is shown in Fig. 3(*b*) as a free body. The width of the contact area between the shackle and its support is taken into account here by regarding the line of action of the force $P/2$ between the support and the free body as at a distance $r/4$ from the center line. Bending deflections are taken into account by assuming that the line of action of the axial force on section A-A is shifted inward one quarter of the shackle leg width. When the distance between the insides of the shackle legs is B and the width of a shackle leg is C, this puts the line of action of the axial force on section A-A at a distance $(2B + C)/4$ from the center line. Section B-B is a circle of radius r as shown in Fig. 3(*c*). Since there is no axial force, the bending moment is equal to the static moment Q_{1b} of the entire cross-sectional area times the yield stress S. However, section A-A, also of radius r as shown in Fig. 3(*d*), is subject to both axial force and bending moment. The limit design condition bending moment is equal to the arithmetical sum Q_{1a} of the static moments of the shaded areas times the yield stress. The limit design condition axial force is the unshaded area A_{2a} times the yield stress. As was done for the hook, the bending moment and axial force will be related by expressing them both in terms of the angle α.

The formulas for the required static moments and areas are:

$$Q_{1a} = \frac{4}{3} r^3 \sin^3 \alpha \quad (12)$$

$$A_{2a} = r^2 (\pi - 2\alpha + \sin 2\alpha) \quad (13)$$

$$Q_{1b} = \frac{4}{3} r^3 \quad (14)$$

Hence, the formulas for the axial forces and bending moments are:

$$M_a = \left[\frac{4}{3} r^3 \sin^3 \alpha\right] S \quad (15)$$

$$P/2 = r^2 (\pi - 2\alpha + \sin 2\alpha) S \quad (16)$$

$$M_b = \left[\frac{4}{3} r^3\right] S \quad (17)$$

Equilibrium requires the following relationship between the moments acting on the free body:

$$\left[\frac{P}{2}\right]\left[\frac{2B + C}{4} - \frac{r}{4}\right] = M_a + M_b \quad (18)$$

Substituting Eqs (15), (16) and (17) into Eq (18) gives:

$$[r^2 (\pi - 2\alpha + \sin 2\alpha)]\left[\frac{2B + C - r}{4}\right] = \frac{3}{4} r^3 \sin^3 \alpha + \frac{4}{3} r^3$$

Dividing by $r^2 (2B + C - r)/4$ gives:

$$\pi - 2\alpha + \sin 2\alpha = \frac{16r \sin^3 \alpha}{3 (2B + C - r)} + \frac{16r}{3 (2B + C - r)}$$

Hence:

$$2\alpha - \sin 2\alpha + \frac{16r}{3 (2B + C - r)} \sin^3 \alpha = \pi - \frac{16r}{3 (2B + C - r)} \quad (19)$$

The value of α obtained by solving Eq (19) can be substituted into Eq (16)

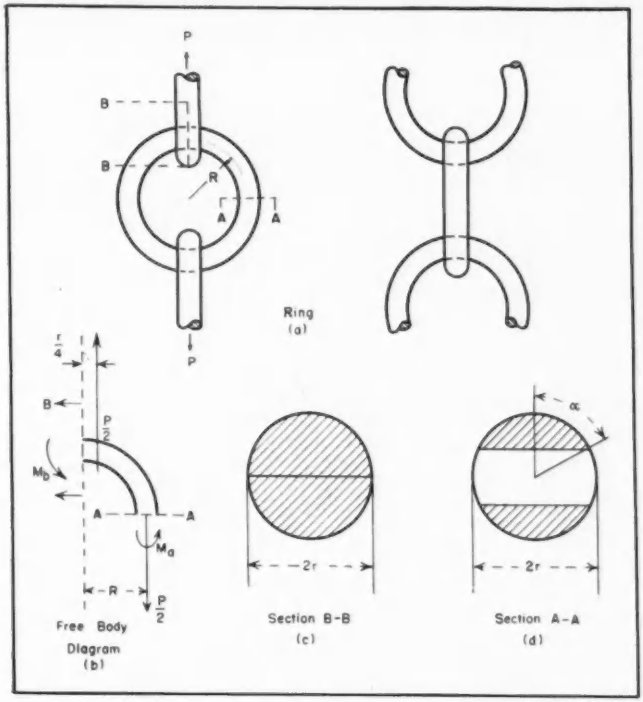


Fig. 4—Ring critical sections thereof and free body under limit design conditions.

to calculate the limit load P.

This method will now be applied to an example for which:

$r = 0.500$ in.
$B = 1.625$ in.
$C = 1.000$ in.
$S = 40{,}000$ psi

Substituting these values into Eq (19) gives:

$$2\alpha - \sin 2\frac{1}{2}\alpha + 0.7111 \sin^2 \alpha = 2.4305$$

Solving this equation gives a value of α of 70.5 deg. Substituting this value in Eq (16) gives a value of P of 26,200 lb for the limit load. This is in good agreement with the value determined by static tests of 27,000 pounds.

It is of interest to note that the limit load is independent of the dimension R. This agrees with observations that chain shackles and anchor shackles of the same size have approximately the same strength.

Analysis of Ring

In Fig. 4(a) are indicated the critical sections of a ring subject to the external load P. The part of the ring between these sections is shown as a free body in Fig. 4(b). The width of the contact area is taken into account by placing the line of action of the force between the free body and the next link at a distance $r/4$ from the center line. The line of action of the axial force through section A-A is at a distance R from the center line. Section B-B, a circle of radius r, is shown in Fig. 4(c). Since there is no axial force through this section, the limit design condition bending moment is equal to the static moment Q_{1b} of the entire cross-sectional area times the yield stress S. In Fig. 4(d) is shown section A-A, also a circle of radius r. Here the limit design condition bending moment is equal to the arithmetical sum Q_{1a} of the static moments of the shaded areas times the yield stress and the axial force is equal to the unshaded area A_{2a} times the yield stress. As before, the bending moment and axial force will be related by expressing them both in terms of the angle α.

The formulas for the required static moments and areas are the same as Eqs (12), (13) and (14). Also the formulas for the axial force and bending moments required are the same as Eqs (15), (16) and (17). The equation expressing the condition that the sum of the moments acting on the free body is equal to zero is:

$$\left[\frac{P}{2}\right]\left[R - \frac{r}{4}\right] = M_a + M_b \qquad (20)$$

Substituting Eqs (15), (16) and (17) into Eq (20) and dividing by S gives:

$$[r^2(\pi - 2\alpha + \sin 2\alpha)]\left[\frac{4R - r}{4}\right] = \left[\frac{4}{3} r^3 \sin^3 \alpha\right] + \left[\frac{r^3}{3}\right]$$

Dividing by $r^3(4R - r)/4$ gives:

$$\pi - 2\alpha + \sin 2\alpha = \frac{16r \sin^3 \alpha}{3(4R - r)} + \frac{16r}{3(4R - r)}$$

Hence:

$$2\alpha - \sin 2\alpha + \frac{16r}{3(4R - r)} \sin^2 \alpha = \pi - \frac{16r}{3(4R - r)} \qquad (21)$$

This method will now be applied to an example for which:

$r = 0.6875$ in.
$R = 3.688$ in.
$S = 40{,}000$ psi.

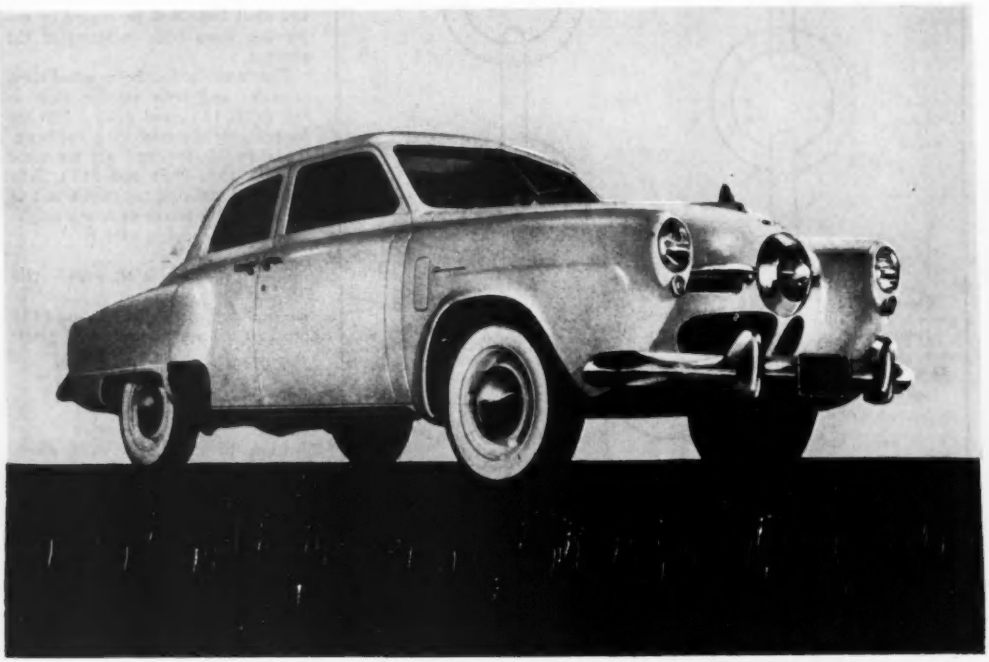
Substituting these values into Eq (21) gives:

$$2\alpha - \sin 2\alpha + 0.2607 \sin^2 \alpha = 2.8809$$

Solving this equation gives a value of α of 82.6 deg. Substituting this value of α into Eq (16) gives a limit load of 19,416 lb. This is in good agreement of the value of 20,000 lb obtained by static tests.

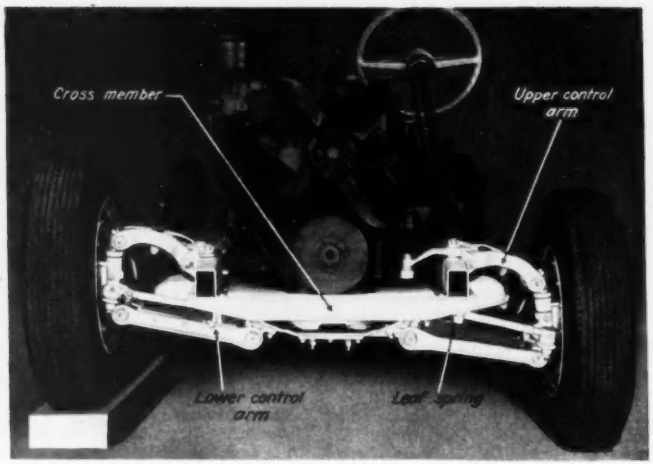
* * * *

ONE OF AMERICA'S first television sets built about 1926, was the brainchild of C. Francis Jenkins of Washington, D. C. The transmitter consisted of a wireless apparatus, a pair of prismatic rings and a selenium cell. The rings projected a point of light from the televized picture to the selenium cell. The latter varied the strength of current flowing through it, and so changed the amplitude of the waves that were sent to a receiver by aerial. Currents set up in the receiver flowed through a coil of wire around a tube filled with carbon disulfide, or light valve, as it was then called. A light ray, passing through the "valve" was varied in the same way and to the same extent as the current flowing through the selenium cell was changed by the light fluctuations that fell on it. The light ray then passed through a ring prism where the rapidly changing graduations of light and shade built up a picture.



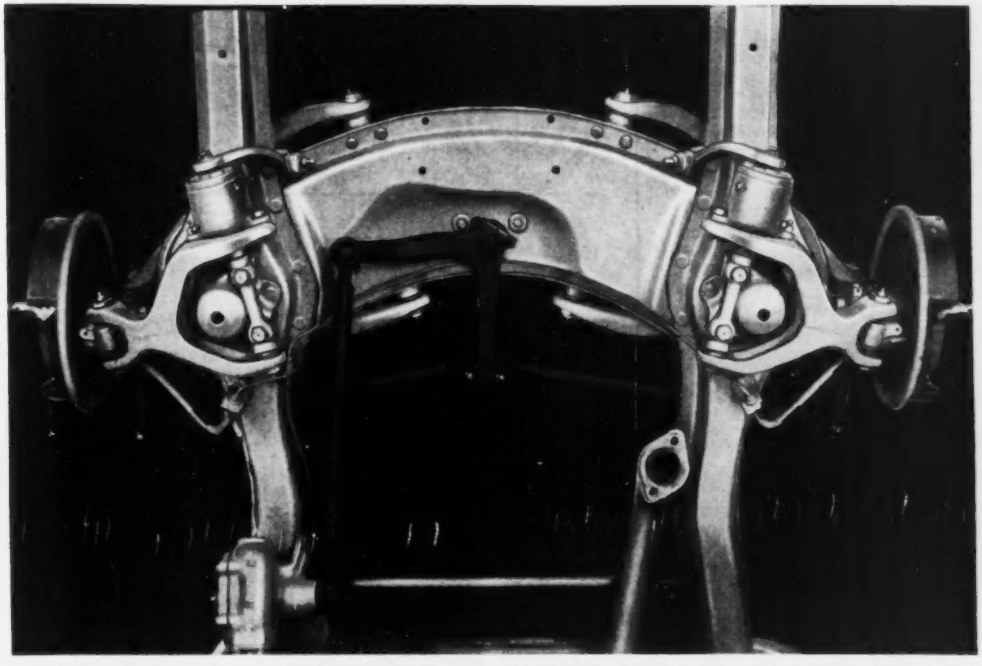
Studebaker Adopts Coil Springs

The front end of the 1950 Studebaker features many changes—in both styling and mechanical construction. A prominent propeller hub emblem and two air scoops give the new cars somewhat of an airplane appearance. Raymond Loewy Associates of New York did the body design. Coil springs replace the front leaf spring used in the previous models. The transmission remains the same, but a torque converter is being readied for introduction probably near the end of the year. Propeller hub dominates front of Champion four-door sedan shown above. The taper of the rear fender has been decreased. Fender tops are now nearly parallel to ground. The remainder of body is unchanged from previous year.

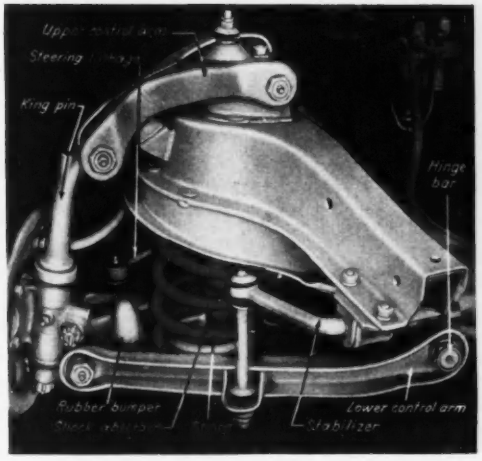


TRANSVERSE LEAF SPRINGS supported front end of 1949 Studebaker. Springs had high load rating but did not give the soft ride characteristic of coil springs. Vertical movement of front wheels was along perpendicular axis.

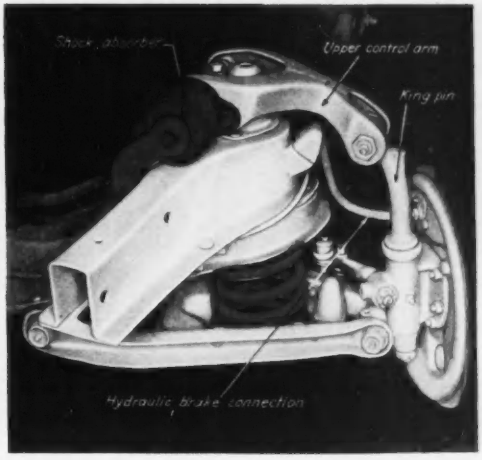
D E S I G N S



INDEPENDENT COIL SPRING front suspension is used for the first time by Studebaker. As previously, leaf springs are used over rear axles. Commander and Land Cruiser models employ centerpoint type steering. The tie rods are equal in length, providing a symmetrical steering mechanism. Champion steering is unchanged.



CHAMPION CHASSIS has direct acting airplane type shock absorbers, which are somewhat easier to install and service than the rotary type.

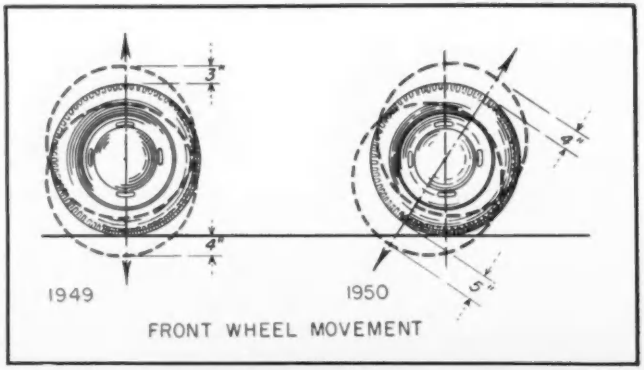


COMMANDER CHASSIS retains the rotary type shock absorbers. The performance of this type shock is somewhat better than airplane type. (*continued on next page*)

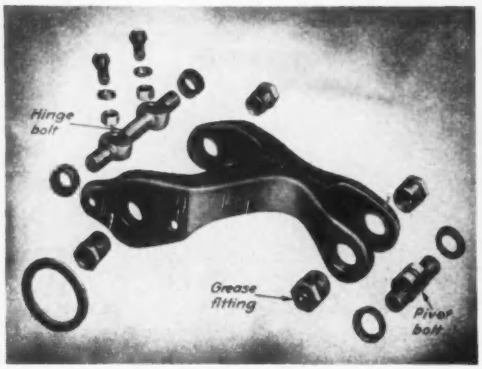
Studebaker

(continued)

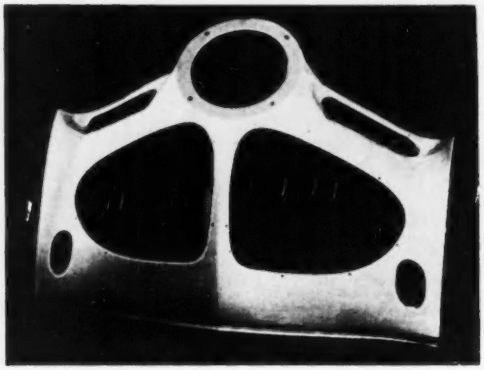
GREATER up and down movement of front wheels over road holes and bumps contributes to improved riding qualities of the 1950 car. This is accomplished by having wheels move along inclined axis. This design permits increased coil spring and shock absorber action before control arms "ground" against the chassis frame. A total wheel travel of 9 in. is now possible as compared with 7 in. on the 1949 models.

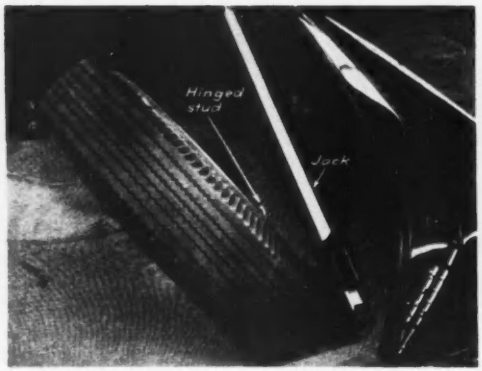


FRONT WHEEL MOVEMENT

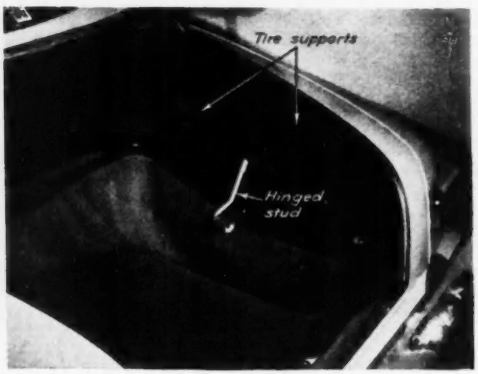


INCLINED MOVEMENT of front wheels is accomplished by placing control arm hinges at an angle with the horizontal. Hinge bolts are mounted in the ends of a stamped cross member. During forming, the ends are twisted slightly to carry hinge bolts at required angle.


GRILLE PANEL STAMPING is rigid by virtue of its shape. Therefore, panel acts as a brace between front fenders. In 1949 cars, grille contributed little strength to body structure. Special stiffeners and cross rods were required to brace fenders and hood.



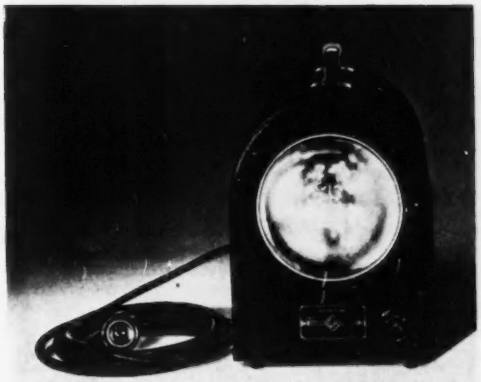
BUMPER JACK acts as back support for spare tire and wheel. Hinged stud and wing bolt clamp wheel securely against jack. Two simple brackets welded to trunk compartment hold the jack in position.

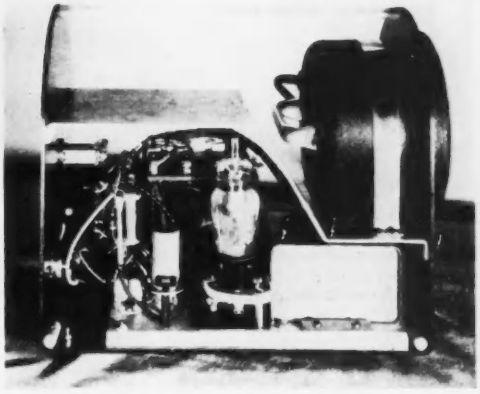


SPARE WHEEL was secured against special supports in 1949 cars. The welding of these supports was difficult since welding fixture had to be maneuvered into wheel house. Jack is now easier to find when needed.

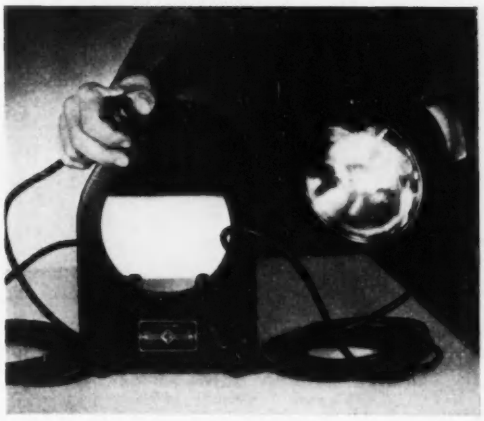
Thumb Switch Controls Flashing Rate of Slow-Speed Stroboscope

Stroboscopic light of low flashing rates is available from the new Strobolume, manufactured by the General Radio Company of Cambridge, Mass. The unit can be operated continuously at speeds ranging from one to 45 flashes per min. Feature of the Strobolume is external control. The user produces the flash of desired frequency by repeatedly pressing a thumb switch. Normally, stroboscopes contain multi-vibrators which are used to generate the light pulses. The speed range of the new device is suited for study of moderate speed mechanisms, textile machinery, fans, propellers and others.

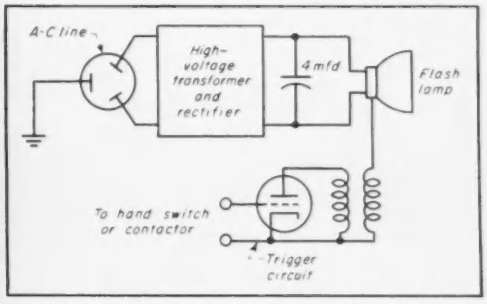




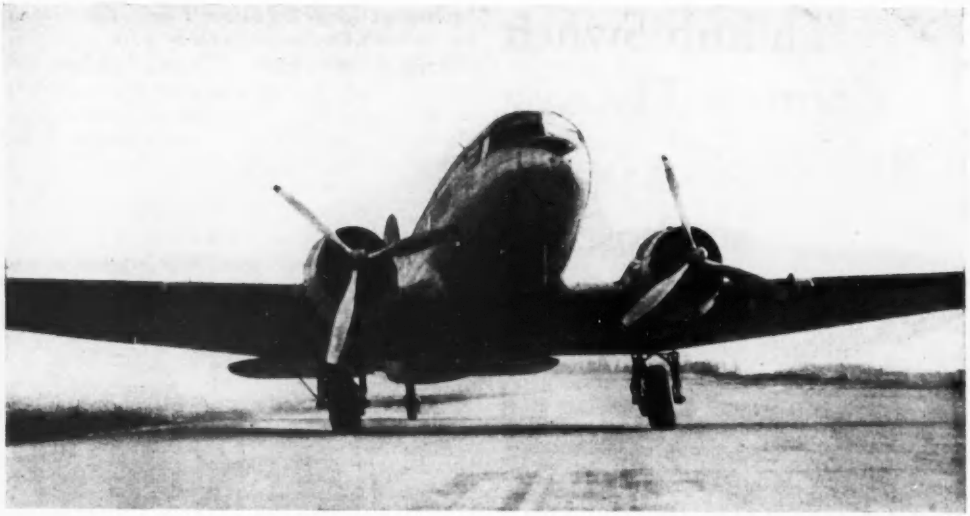
CASE OF THIS PORTABLE INSTRUMENT is wrinkle finished for durability. The slow speed operation makes it possible for lamp to withstand a high intensity flash. For this reason, the Strobolume has been designed to give a light intensity almost 10 times greater than standard stroboscopes. All components are compactly arranged within stroboscope case. The instantaneous potential across the lamp at flash is 2,500 volts.



LAMP ASSEMBLY is removable by release of knob-operated locking clamp. The instrument can be flashed at speeds over 45 per min, but not continuously. Intense flashes may be obtained up to 1,200 per min. At the higher speeds, the components rapidly overheat.



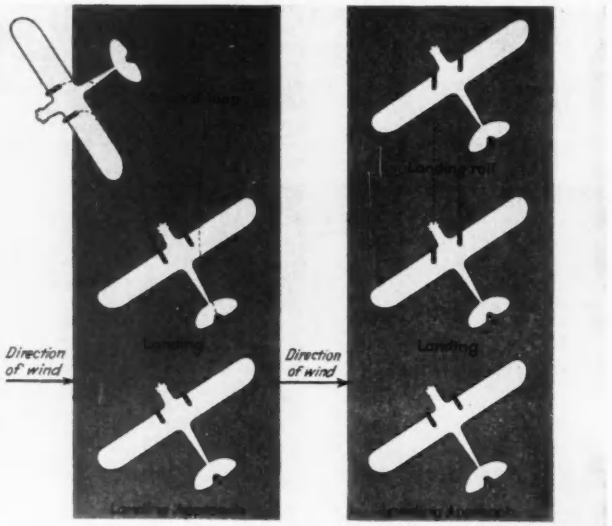
POWER SUPPLY for stroboscope consists of conventional transformer and rectifier. This charges the 4 mfd capacitor to about 2,500 volts. The capacitor remains charged until a pulse from the trigger circuit, operating through a spark coil, ionizes the gas in the flash lamp. This initiates the discharge of the capacitor through the lamp, producing the flash. The constants of the circuit and the flash tube are designed so duration of flash is between 10 and 15 microseconds. For higher speeds, hand switch is replaced by vibrator or other timing device. Each flash consumes two watt-seconds of energy.



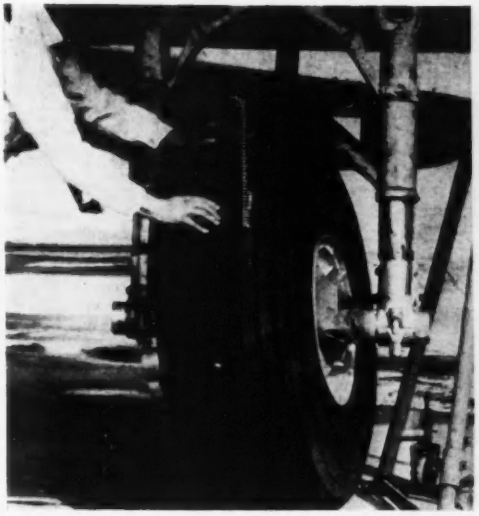
NOSE OF TAXIING DC-3 remains pointed into cross-wind while wheels roll directly down runway. No controls are required for operation of the wheels. They adjust themselves automatically upon contact with the runway. Each wheel casters independently so that touch-down of one wheel slightly before the other will not affect the cross-wind landing operation. Larger size wheels are equipped with hydraulic locks which permit pilot to select fixed wheel or castering operation. Goodyear's Aviation Products Division is located in Akron, Ohio.

Castered Wheels for Cross-Wind Landings

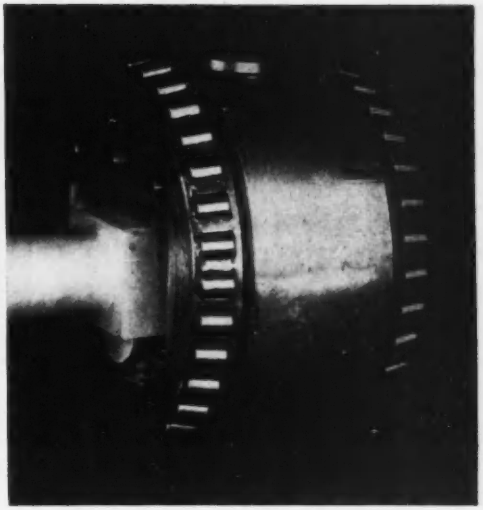
Airplane wheels developed by the Goodyear Tire and Rubber Company simplify landings made while wind direction is across the runway. In such cross-wind landings the new wheels automatically align themselves with the runway although the plane is kept headed into the wind. A castering mechanism is incorporated within the hub of each cross wind wheel. The mechanism includes a cam and spring arrangement which keeps the wheels centered during slow taxiing, routine landings and after take-off.



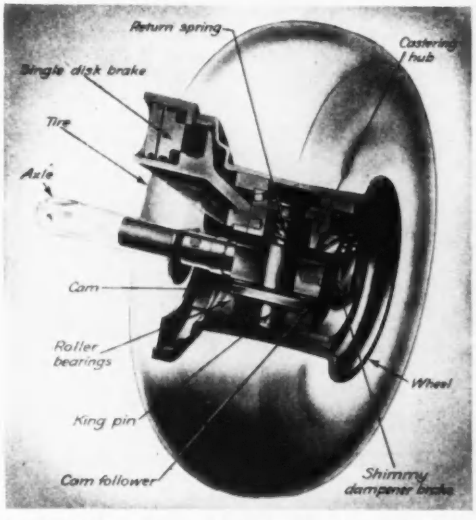
PLANES attempting to land in a cross-wind must head into wind to maintain a course in line with runway. In planes equipped with conventional gear, pilot aligns himself with runway just before touchdown. Otherwise, plane may skid or ground loop. With new wheels, pilot keeps plane pointed into wind until completion of the landing roll.



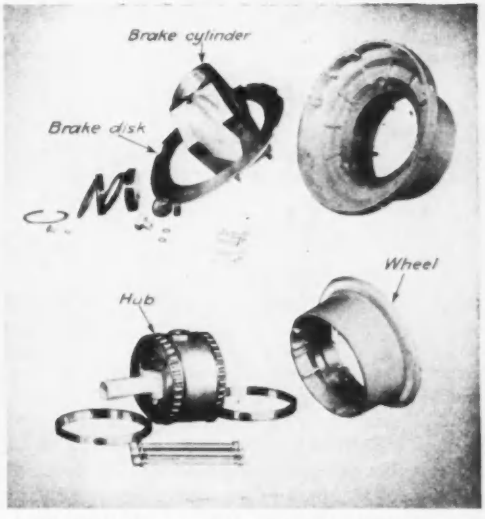
MAXIMUM CASTER of landing wheel is 15 deg on either side of center. The two struts which support each wheel of the DC-3 are fixed in position. Use of the cross-wind wheel, which carries 17.00-16 in. tires, does not change braking technique.



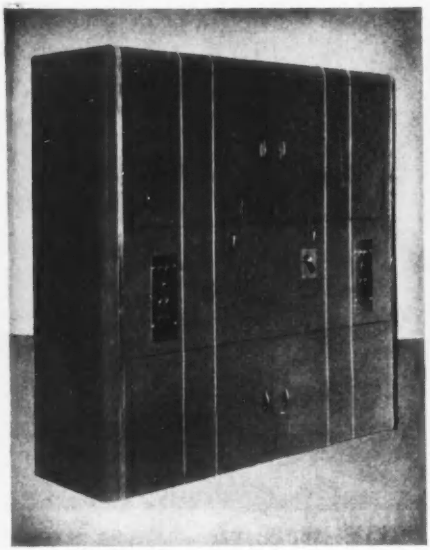
COMPLETE CASTERING mechanism is contained within wheel hub. Wheels ride on twin rows of roller bearings mounted in hub. Cross-wind wheels of appropriate size can be added to any existing model airplane. No control connections or strut changes are involved.



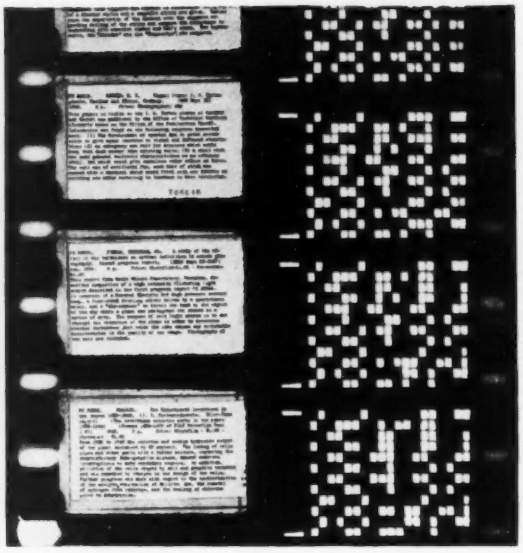
KING PIN passes through the wheel center so that brake application cannot make the wheel caster. The king pin is inclined with its lower end forward. Thus, wheels caster automatically to compensate for angle between axes of runway and airplane. The king pin angle is 30 deg in the "tail-low" position. This is sufficient to provide the desired pivoting effect regardless of height of tail above ground at wheel touchdown. Large angle also precludes any tendency of wheel to reverse under load.



DISK BRAKES are used in castered wheels. Hub carries the brake cylinder while the disk is splined to the wheel. Entire weight of the airplane rests on a cam located below lower side of the axle. Whenever the wheel casters, cam followers raise plane slightly. This provides a small force that resists the castering of the wheels from their mid-position. This resistance keeps wheels parallel when plane is pushed backwards or taxied at low speeds. Spring at the top of king pin centers wheels when plane is airborne.



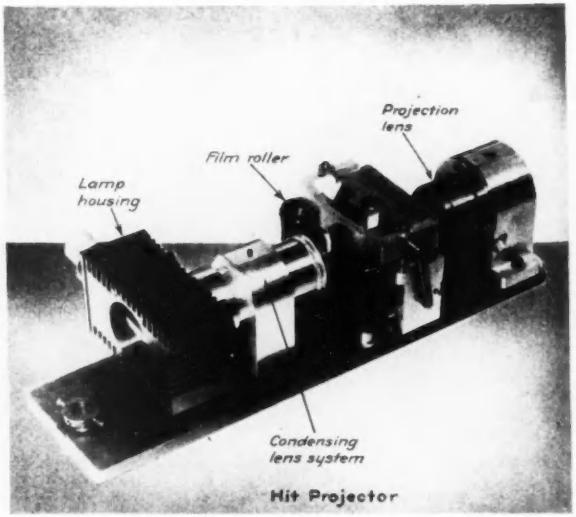
COMPLETE MACHINE is enclosed in sheet steel cabinet. The operator inserts a master code card into the machine before starting. This code card determines the subject under search. Machine delivers the requested data on a strip of film.



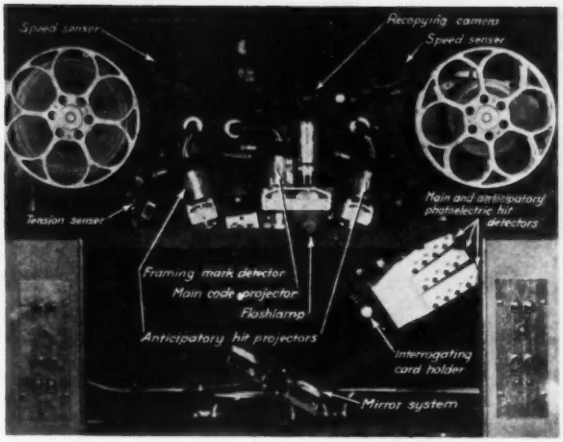
FILE CARDS containing abstracted data are recorded on 35 mm film. To the right of each abstract is a pattern of black and white squares. Pattern varies with the subject matter and constitutes the code for identifying an abstract. The light source used for scanning the code areas is a 90 watt lamp.

Photoelectric Cells Sift Microfilm Records

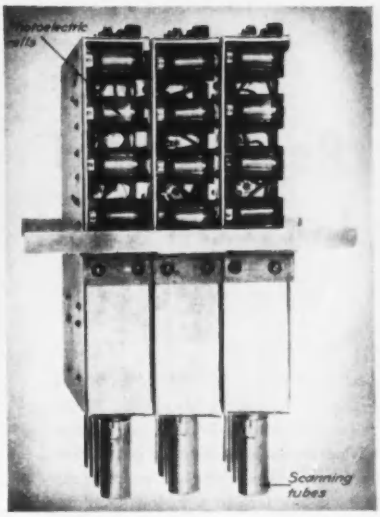
At the press of a button, this machine will search through a huge microfilm library for material pertaining to a specific subject. The contents of almost 500,000 file cards can be stored by the machine on a single reel of film. A search of the entire library can be completed in less than 10 min. All pertinent data located by the machine is photographed automatically and delivered to the operator. Known as the Microfilm Rapid Selector, the device was developed jointly by the U. S. Departments of Commerce and Agriculture from principles originated by Dr. Vannevar Bush.



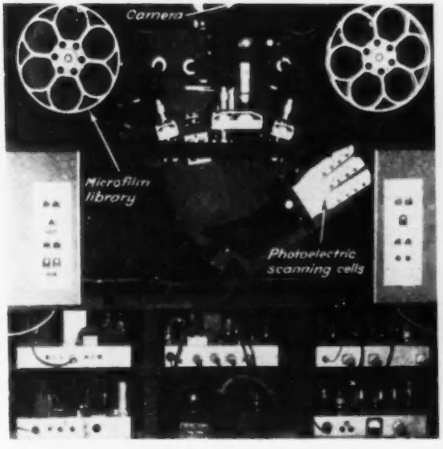
MICROFILM passes through three projecting units which throw image of the code pattern against the master code card or interrogating card. The pattern on any particular master code card is exactly complementary to the corresponding code pattern on the microfilm library. When the film code area dot-pattern and the punched card are exactly complementary, no light passes through the card holes, a blackout occurs and a "hit" is detected by the photoelectric cells.



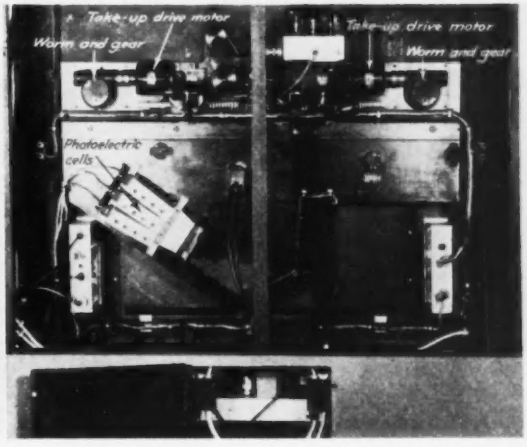
THE TWO anticipatory hit detectors are identical to main hit detector up to the point of interpretation and use of blackout signals. The interpretation circuits for the anticipatory detectors watch the time interval between consecutive hits. If this interval is less than the 1/30 of a sec required for the recopying camera to advance, a pulse is generated which slows the film drive from normal speed of 300 fpm (180 frames per sec) to 50 fpm (30 frames per sec). The hit detector operates in conjunction with the framing-mark detector. In order that the abstract will be properly positioned for photographing, it is necessary that the flash lamp and camera be actuated by a uniformly placed mark on the microfilm rather than by the hit itself. A hit merely prepares a storage system for triggering by the framing mark detector, which utilizes a separate light projector and photo cell. Reel drive motors are rated at 1/10 horsepower.



FOUR photoelectric cells are used in each hit detector. Each cell scans ¼ of the projected code area after screening by the interrogating card. These cells feed into electronic circuits which recognize simultaneous blackout of the cells and furnish an actuating pulse to the flash lamp and recopying camera circuits. The original design used one cell for the whole area. But the single cell had to be sensitive and sometimes responded to stray light.



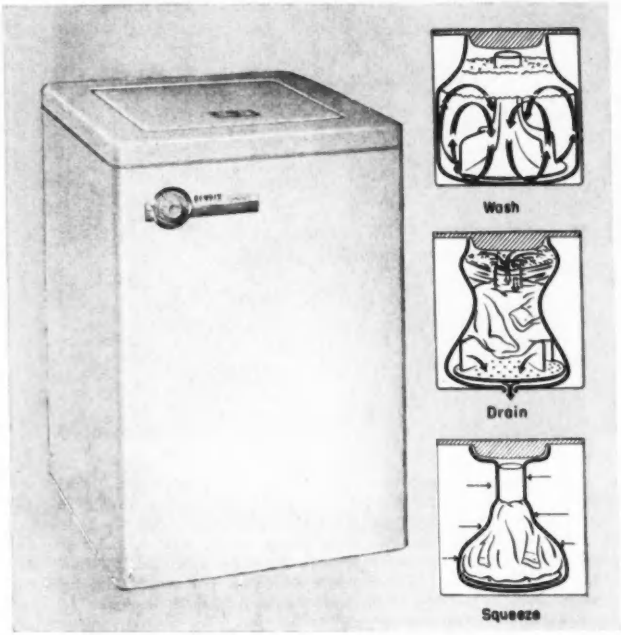
PHOTOELECTRIC CELLS scan the code patterns on the microfilm. These cells are coupled electromechanically to a high speed flash lamp and a rapid advance camera. When the cells detect the proper code pattern, the flash lamp and camera operate. Thus, appropriate information is transferred from the master film to a second film.



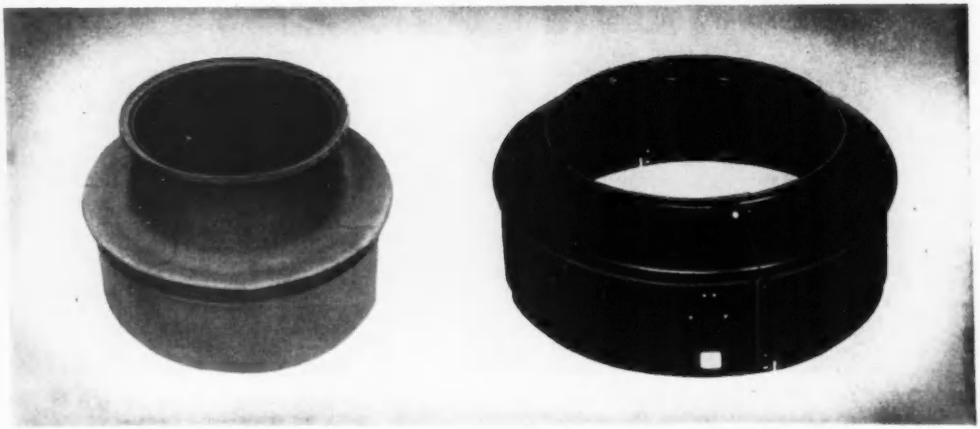
SEPARATE MOTORS drive take-up and pay-out reels of the microfilm library through worm and gear train. Film tension is maintained by pull of only one lb for minimum wear. Early tests showed that roller inertia overcame this light pull during speed changes, forming slack loops of film. Designers corrected this by using fewer rollers and making them of thin-walled aluminum tubing.

Rubber Replaces Steel For Low-Cost Washer Tub

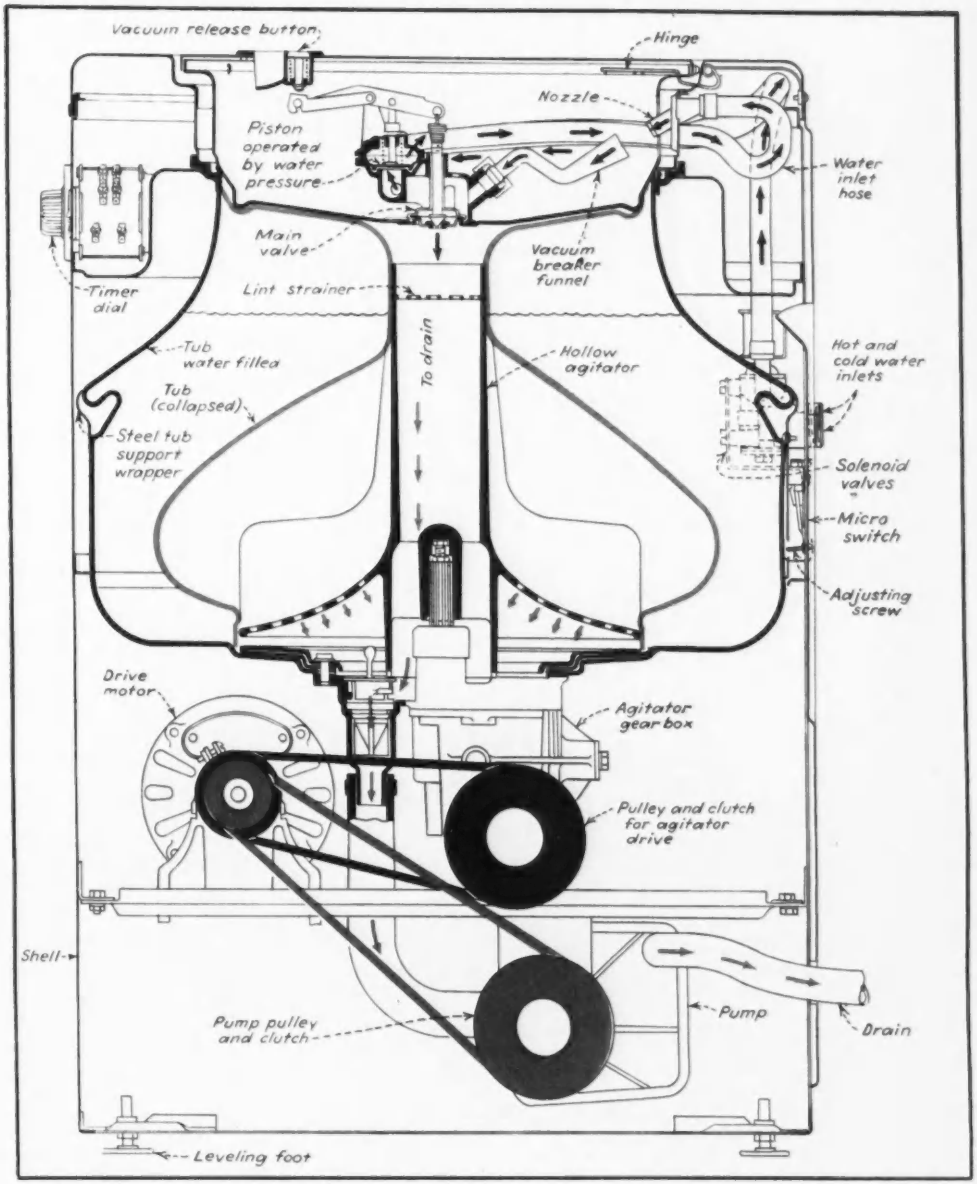
The low price of the Bendix Economat is due entirely to clever design. Many major departures from conventional washer design are combined in the new machine—priced far below previous models. In place of a basket spinning at high speeds, the washer uses a flexible rubber tub to squeeze water from the clothes. A second feature is the substitution of two overrunning clutches for expensive solenoids and gear shifting mechanisms. A reversible drive motor; a single unit that pumps both water and air; and a water-powered vacuum release mechanism are other cost-saving elements. Bendix Home Appliance, Inc., is in South Bend, Indiana.



WASHER IS LOADED through top. This is departure from other Bendix machines, which are designed for front loading. Cabinet finish is in white enamel baked on steel. Water and air are pumped from machine after each washing or rinsing phase. Atmospheric pressure collapses the rubber tub against the wet clothes. Thus, clothes are squeezed between the tub and the agitator. This design eliminates the high speed spin used by other automatic washers for water extraction. Thus, washer does not vibrate sufficiently to require bolting down.



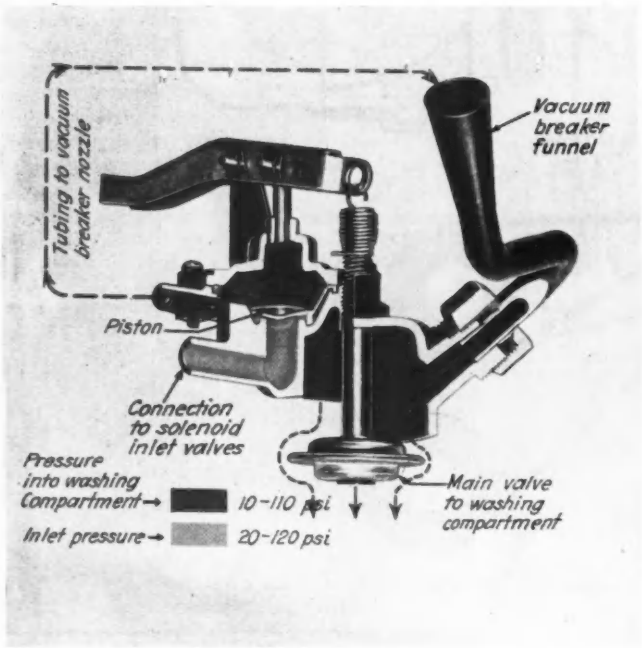
FLEXIBLE RUBBER TUB holds water and clothes during various wash cycles. Tub is molded in one piece by the General Tire & Rubber Company. Despite continued flexing and abrasion from clothes and buttons, Bendix guarantees tub will last at least 5 years. Steel tub-support wrapper (right) is mounted within exterior shell of washer. This wrapper limits tub's expansion when being filled with water.



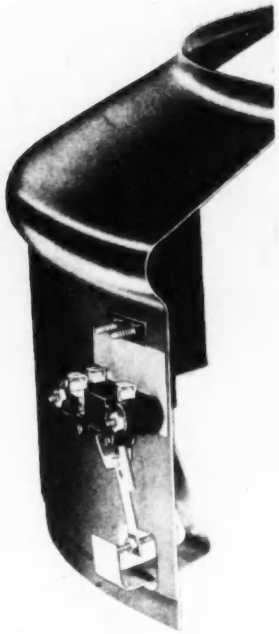
REVERSIBLE, split-phase motor drives both agitator and pump pulleys. This is standard practice in other Bendix washers where pump and tumbling cylinder operate continuously. A solenoid valve cuts the pump in or out of the system as required. But in the new machine, the agitator and pump must never operate simultaneously—for obvious reasons. Bendix engineers considered various schemes that would permit independent operation of agitator and pump. Any one of several designs could have been selected to accomplish perfectly the desired result. To keep the cost of the product down, these were discarded in favor of low-cost overrunning clutches. Both agitator and pump pulleys have overrunning clutches. Pump pulleys, shown in red, carry load only when rotation is counter-clockwise. Agitator is in operation only when its associated pulleys, outlined in solid black, rotate clockwise. A simple reversing switch in the motor circuit can thus control pump and agitator. (*continued on next page*)

Washer (continued)

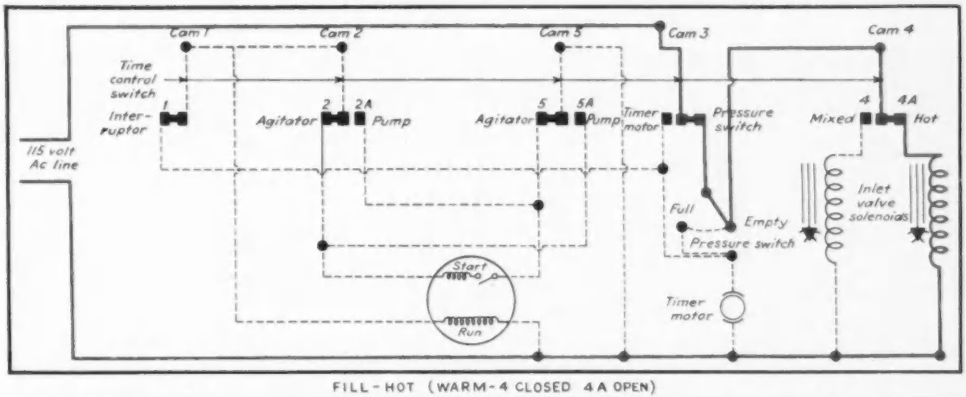
CLUTCH ADAPTER passes through pulley hub and connects to pump shaft. When pulley rotates clockwise, spring revolves loosely over adapter shaft. Upon reversal, the pulley catches a projection on one end of the coil and winds it tightly over pulley hub and adapter shaft. This transmits torque to pump shaft. The clutch spring is coiled from highly flexible, small diameter wire. The agitator clutch spring is wound in the opposite direction.



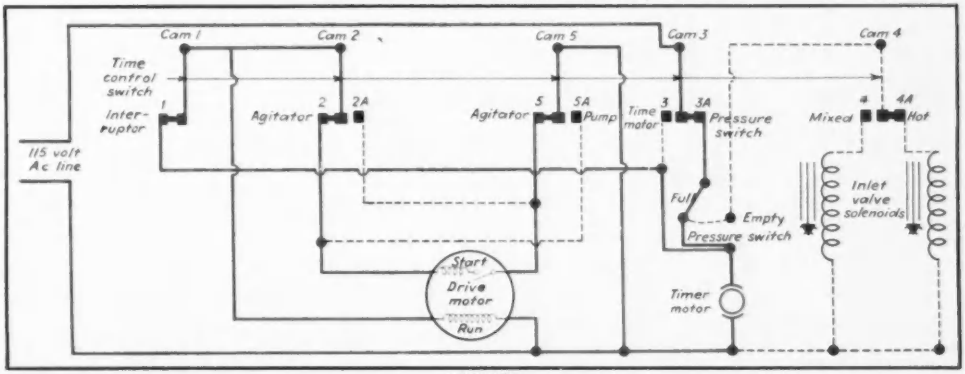
DESIGN FOR COST REDUCTION is evident again in vacuuum release assembly. After squeeze phase, main valve is held tightly shut by vacuum in machine. To avoid use of a heavy, expensive solenoid to open the valve, Bendix engineers harnessed water power for the job. When the inlet valves are opened, water pressure reacts against piston, opening main valve. Water flows past piston, through hose into vacuum breaker nozzle and funnel, then into washer tub. A finger button in top plate releases the tub vacuum at the end of the complete wash.



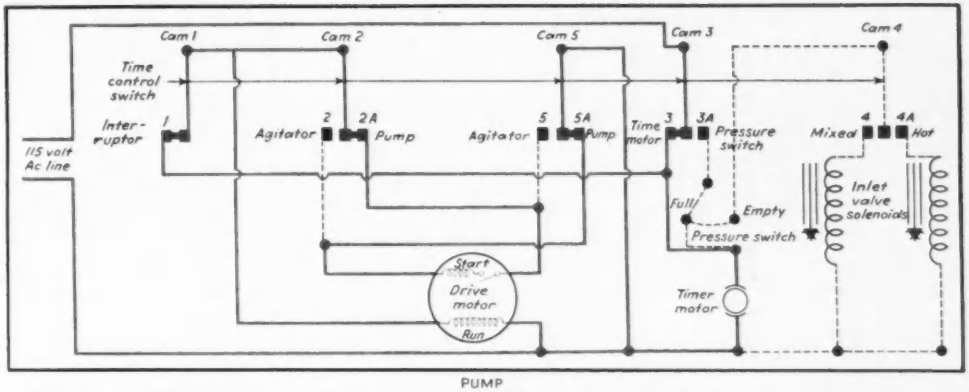
PRESSURE SWITCH installed on tub support wrapper is actuated by pressure of water within the rubber tub. This switch controls the amount of water entering the tub. A second function is to prevent operation of the agitator unless the tub is sufficiently full.



FILL - HOT (WARM - 4 CLOSED 4A OPEN)



AGITATE

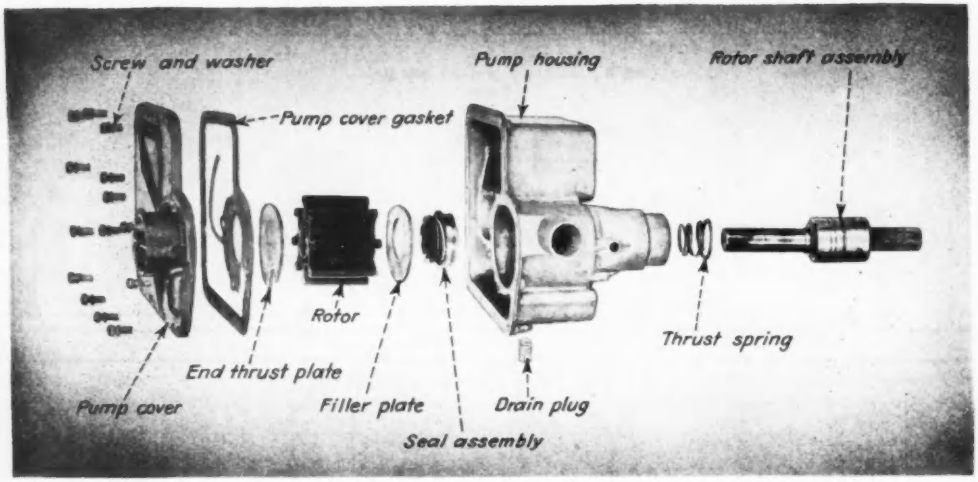


PUMP

ACTIVE CIRCUITS for various cycles are shown above in red. When washer is first started, timer motor is not energized and cams do not advance. Only the inlet valve solenoids are active. When tub is filled, it snaps a pressure switch which closes timer and drive-motor circuits. Single-pole, double-throw switches control direction of drive motor rotation—which in turn determines whether pump or agitator will be in operation. In order to reverse motor, it is necessary first to bring it to a complete stop. This is accomplished by the cam-operated interruptor switch in the drive motor line. Before each change of direction, the interruptor opens the circuit for a period of about 28 sec. This is sufficient to assure stopping of motor before reversal.

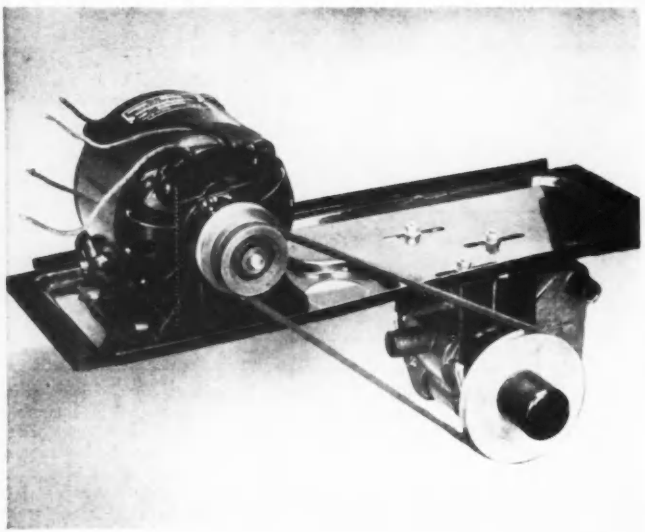
(*continued on next page*)

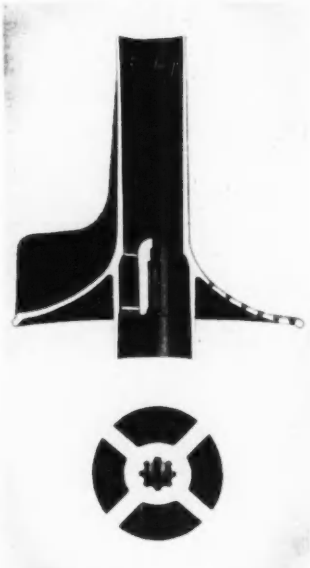
Low Cost Washer Tub (continued)



COMBINATION water and vacuum pump is manufactured by Thompson Products of Cleveland. Pump capacity is 10 gpm and 25 in. of mercury. The pump contains a rubber-bladed impeller having 8 vanes. The impeller rotates in cylindrical chamber, one side of which has been flattened to give a flexing action to the blades. Expansion and contraction of the spaces between vanes produce suction. The eccentric impeller chamber is cast within a larger housing. This larger chamber traps and retains a quantity of water for impeller lubrication when pump is pulling air.

MOUNTING CHANNEL near base of machine carries motor and pump. The slots stamped into the channel permit adjustment of belt tension. The motor drives pump at 835 rpm and the agitator transmission pulley at 1,060 rpm. This is accomplished by different diameters of the double-groove drive pulley mounted on the motor shaft.

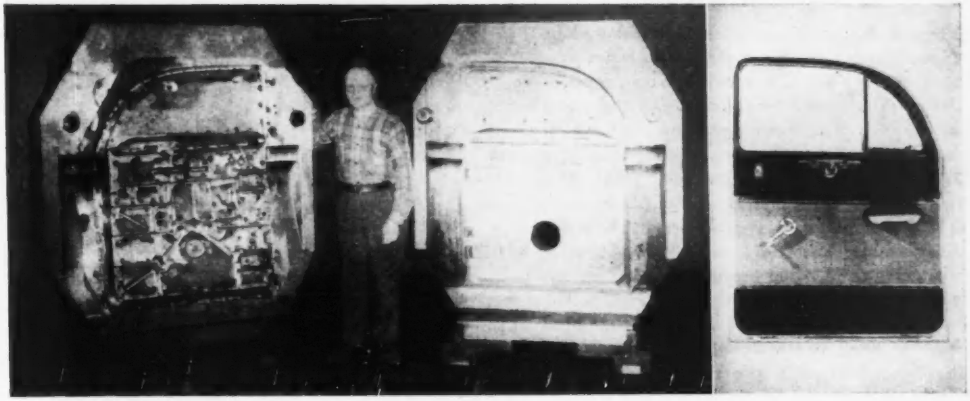




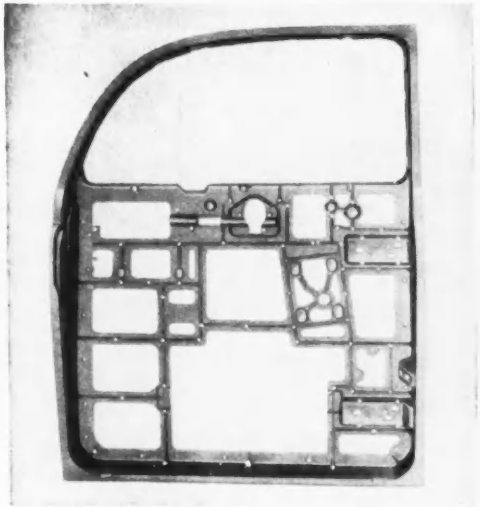
SPLINED HUB of one-piece plastic agitator mates directly with output shaft of the cranking mechanism. Tests show that should agitator become jammed, plastic splines are strong enough to stall the drive motor without breakage. Floating scum drains through hollow agitator hub. The heavier sediment passes out through holes in the bottom of the agitator blades.

Big Die Casting Cuts Cost Of Automobile Door

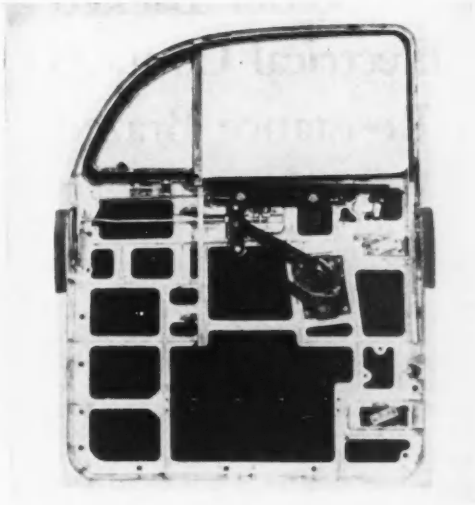
Basic structure of the new Kaiser-Frazer car doors is a one-piece aluminum die casting. The Doehler-Jarvis Corporation of N. Y. C., co-designer and maker of the die casting, says it is the largest in area ever produced. Conventional doors are built over frames fabricated from steel sheet and channel sections. The new design has reduced assembly costs and car weight.



DIE FOR MAKING DOOR FRAMES weighs approximately 13 tons. The completed door is shown on the right. Because of the dimensional uniformity characteristic of die castings, the finished door can be held closely to the shape and size established by its designers. This is not so where welded sheet steel frames are used and adjustments are frequently required for improperly fitting doors. Die cast doors can be assembled without refitting.

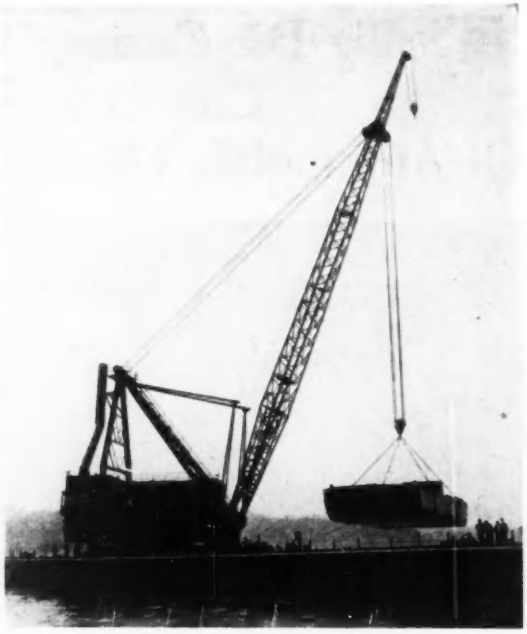


AFTER TRIMMING, aluminum alloy casting weighs about 12 lb. The completed door is now almost 9 lb less than before. Reinforcing ribs—difficult to obtain in sheet metal construction—are used freely in new design.



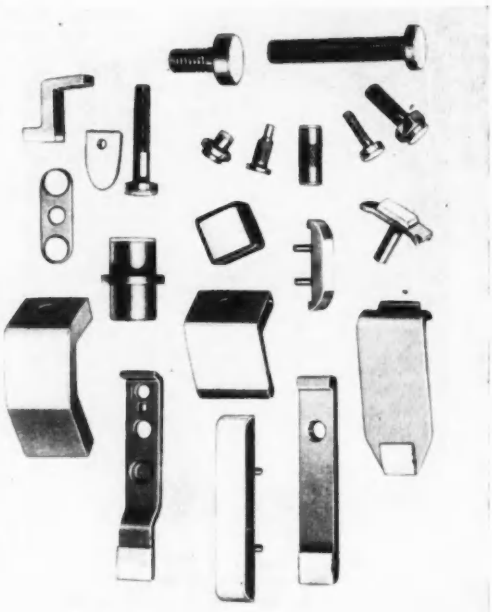
DIE CASTING is chassis for steel outer shell, window and lock mechanisms and upholstery. Doors having the die cast frame lack the "tinny" sound characteristics of many conventional doors when they are slammed.

High-Strength Steel Lowers the Boom Weight 16 Percent



Through the use of smaller sections of low-alloy, high-strength steel, the boom of this steam-powered crane weighs 16.3 percent less than previous designs. The boom is 195 ft long and is constructed with 8 x 8 x 1 in. chord angles and 6 x 6 x $\frac{3}{4}$ in. lacing angles. The new material effected a saving of 25 percent of the deadweight of the chords. High strength steel was also used in the A-frame, which is composed of 21 in. wide-flange beams. The Wiley Engineering Company of Port Deposit, Md., manufactures the 2,225 ton floating crane. Lifting capacity of the crane is 150 tons at 80 ft. radius. The welded steel barge on which the crane is mounted is 300 ft along, 90 ft wide and 14 ft deep. Bethlehem Steel Company's Mayari R is the material See October issue for article on these steels.

Solder Backed Electrical Contacts Resistance Brazed To Their Supports



Fine silver and coin silver electrical contacts made by the Gibson Electric Company are backed with Easy Flo, Sil Fos or RT solders. Also a sintered silver-nickel contact backed with Sil Fos or RT solder is available. These contacts have all the advantages of conventional brazed contacts but do not require a separate piece of solder in the brazing operation. The contacts are brazed to the screws, studs, fingers, blades or other support in a reduced atmosphere furnace or by electric resistance brazing. The Sil Fos backed contacts can be electric resistance brazed without the use of a flux. Electric resistance brazing results in a bond that is superior to projection welding or riveting.

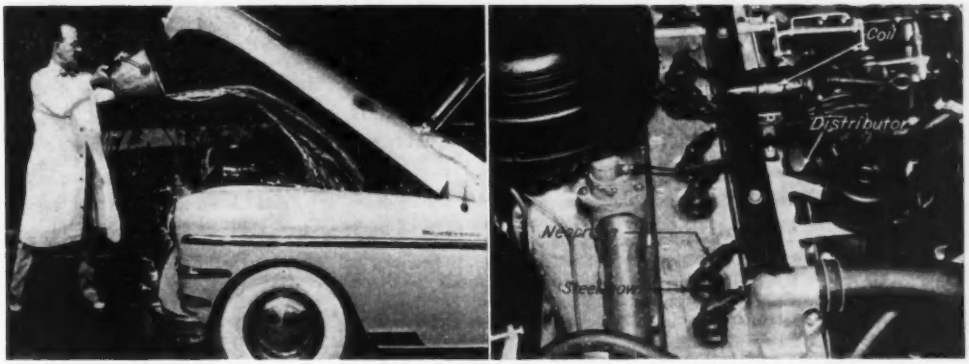
Phenolic Moldings Cut Fan Cost, Weight

Use of high-impact molded phenolics in this fan reduced its weight by one half. The manufacturer, Roto-Beam of Chicago, states that the new design has halved production costs. The five-bladed 10 in. propeller, motor housing and fan base are plastic. Since propeller weighs only 8 oz, a lower horsepower motor can be used to obtain rated performance. The propeller is accurately pre-balanced in the mold so that it needs no finishing operations. The original propeller blade was made of cast aluminum, which could not be produced to close enough tolerances. Each blade had to be balanced, polished and plated individually. Seventy percent of the aluminum propellers passed inspection, and 25 percent of those accepted were returned for repairs after a short period of service.

Bakelite Corporation

ACOUSTICAL CHARACTERISTICS and balance of the plastic make the fan practically noiseless and vibration free. Shown here are top and bottom views of the base, blade, and motor housing. At the top is the same fan supplied with a mounting bracket that enables it to be attached to an oil burner or other heating unit.

Neoprene Sleeves Waterproof Ignition System



WATER BATH does not stall the engine of the 1949 Chrysler car. A water-proof ignition system prevents moisture from contacting the sparkplugs, wiring or distributor where it might short circuit the sparkplugs and prevent their firing. The waterproofing improves the car's performance in rain-storms and over flooded roads. Each sparkplug is completely protected by a neoprene synthetic rubber cover and a steel bowl. Ignition wiring is neoprene covered and the distributor connections are sealed with synthetic rubber caps.

Brooks and Perkins, Inc.

PICKLING a fabricated magnesium dome prior to painting. Chemical treatments increase corrosion resistance and paint adhesion.

Inorganic Finishes for Light Metals

Practical considerations such as cost and availability make selection of inorganic coatings for metallic materials quite different than if based solely on theoretical factors such as electromotive potential. Optimum corrosion protection for the light metals, discussed in this first article, are the chemical treatments.

JEROME L. BLEIWEIS
Metal Finishing Consultant

CHOICE OF A PARTICULAR TYPE of inorganic coating for a specific metallic material is based on consideration of both functional aspects and the economic latitude permitted for finishing the product. To make the best choice, the design engineer should become familiar with established coating processes, their relative costs, and their applications.

There are two types of inorganic coatings of importance for engineering applications. Electroplated metallic coatings, and the oxide or chemical "conversion" coatings. These can be applied to the light metals, the copper alloy group, the ferrous group, zinc die castings, and the lead base alloys. Some of the more unusual coating applications will be considered separately.

Magnesium

A major problem in using magnesium alloys is corrosion prevention. The condensed Electromotive Force Series in Table I shows that magnesium is most chemically active of the structural metals. Metals with a higher electronegative potential have greater chemical activity; thus, when two metals are in contact, the less electronegative is protected by the more electronegative metal, which is "sacrificed."

Table I is a theoretical listing, based on the potential of an electrode of the material in a one molar solution of its ions, referred to the normal hydrogen electrode at 25 C. A more practical series, derived from corrosion data, is shown in Table II. When any two dissimilar metals are in contact, there is some accelerated corrosion of one by the other. However, metals within groups bounded by the dotted lines do not corrode each other by galvanic action to any great extent; but metals in groups lower in the table will cause

American Magnesium Corp., Subsidiary Aluminum Co. of America

TYPICAL MAGNESIUM aircraft parts, after chrome pickle treatment for corrosion protection of surface, and as a base for paint. This treatment is simple and inexpensive.

Table I—Electromotive Force (E.M.F.) Series

Metal	Potential, volts
Lithium	−2.959
Rubidium	−2.925
Potassium	−2.924
Calcium	−2.76
Sodium	−2.714
Magnesium	−1.8
Aluminum	−1.337
Zinc	−0.761
Chromium	−0.557
Iron (ferrous)	−0.44
Cadmium	−0.401
Cobalt	−0.23
Nickel	−0.20
Tin	−0.136
Lead	−0.122
Hydrogen	−0.00
Copper	0.344
Silver	0.797
Platinum	0.86
Gold	1.36

Table II—Practical E.M.F. Series

Magnesium Aluminum
Zinc Cadmium Iron Corrosion-Resistant Steels (active)
Soft solder Tin
Lead Nickel Brass Bronze Nickel-Copper alloys Copper
Corrosion-Resistant Steels (passive)
Silver solder
Silver Gold Platinum

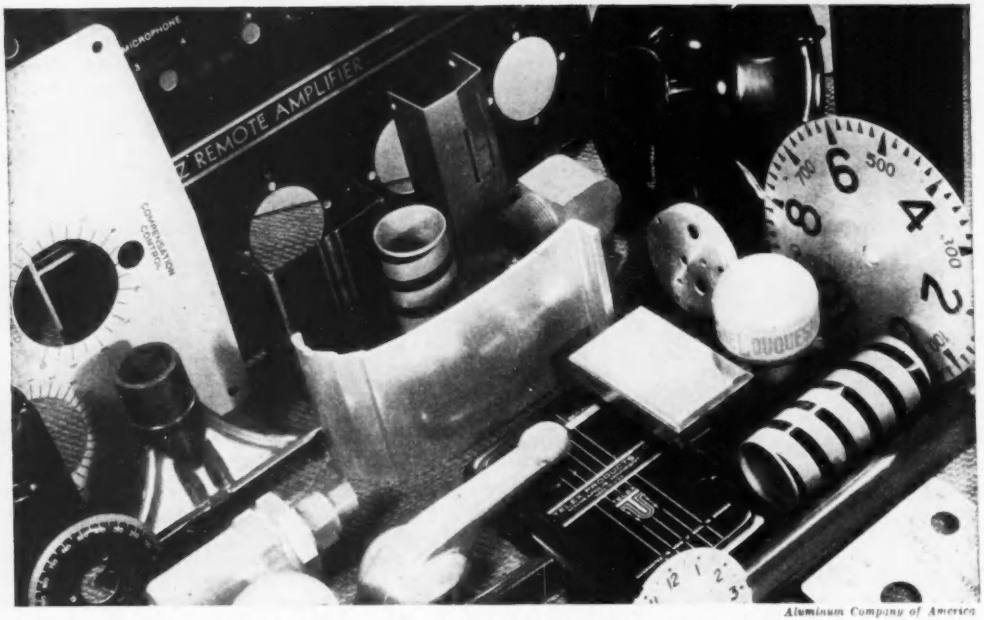
markedly increased corrosion of metals in groups higher in the table, when both are in contact. Thus magnesium cannot be protected by electroplating with any other metal below it in the series; even zinc and cadmium, which are most often plated on metals for corrosion protection, are in a group below magnesium.

The only way to adequately protect magnesium from corrosion by electroplating is to plate a coating heavy and pore-free enough, which prevents the initiation of galvanic corrosion by complete physical exclusion of the atmosphere. This approach is costly, and is used only when the decorative aspects of the product are important enough to warrant plating. When corrosion resistance is the primary consideration, it is preferable to apply "oxidized" conversion coatings by controlled corrosion of the magnesium surface, forming impervious films that retard further corrosion. For even better corrosion resistance, organic coatings are applied over the oxide finishes.

The activity of magnesium under widely different conditions and environments determines the selection of corrosion-retarding coatings for magnesium.

In inland environments, magnesium can withstand the deteriorating effects of corrosion for many years, with little loss in physical properties. Although not quite as good as aluminum in this respect, magnesium forms a fairly impervious "self-healing" oxide coating in inland environments. Generally, magnesium corrodes more rapidly in coastal or marine atmospheres than in inland areas. Chlorides are particularly severe in their attack on magnesium; prolonged exposure to a salt spray atmosphere results in bulky non-adherent corrosion products. Thus, in salt water or marine environments, it is advisable to find the best protection for magnesium, regardless of cost. The following procedure is the best solution for this type of problem, with magnesium: First, apply the best oxide coating available; then, apply one or more zinc chromate primer coatings; finally, apply a good organic top coat.

Alloys of magnesium do not corrode in solutions of chromates, chromic acid, fluorides, borates, or alkalies under most conditions. Most mineral acids attack magnesium vigorously. A tabulation of the qualitative reactivity of magnesium in various chemical environments can be found on pages 242-246 of the book "Designing with Magnesium", published in 1947 by the



Aluminum Company of America

FOR MAXIMUM CORROSION RESISTANCE, anodized films are best on aluminum. These parts have been finished by the sulfuric acid anodizing (Alumilite) process. Such coatings can be dyed, with beautiful, permanent colors resulting.

American Magnesium Corporation, subsidiary of Aluminum Company of America.

The "conversion" or chemical surface coatings are the most important protective treatments for magnesium. The most widely used chemical treatments for magnesium are the processes utilizing chromates and dichromates as the active coating forming materials. Best known of these are the Chrome-Pickle (Dow Treatment No. 1 or AMC Treatment A), Dichromate (Dow Treatment No. 7 or AMC Treatment G;) and Modified Alkaline-Dichromate (Dow Treatment No. 8 or AMC Treatment H). Of these, the most inexpensive to operate and prepare, and the simplest and most rapidly applied coating is the chrome-pickle treatment. It is used primarily for corrosion protection on rough castings, sheet, extrusions and forgings during storage, shipment, and machining.

Chrome pickle coatings are also used as mordants for dyes for color ornamentation, and as bases for lacquer or paint on surfaces that need not be held to close dimensional tolerances. Etching results from the treatment, frequently with 0.0006 to 0.001 in. of metallic surface removed during treatment.

A modified solution in which dimensional loss is reduced is also available. The treatment consists of immersing the properly cleaned parts, for ½ to 2 min if unmachined and 15 sec if machined (and close dimensions must be maintained), in the following bath:

Sodium dichromate ($Na_2Cr_2O_7.2H_2O$)	1.5 lb
Nitric Acid (HNO_3, sp. gr. 1.42)	1.5 pints
Water	to make 1 gal.

For finish-machined parts, where practically no dimensional loss can be tolerated, the pieces can be dipped for 15 sec in a milder bath:

Sodium dichromate ($Na_2Cr_2O_7.2H_2O$)	0.75 lb
Nitric Acid (HNO_3, sp. gr. 1.42)	0.50 pint
Water	to make 1 gal.

The baths are operated at room temperature and are held in earthenware, aluminum or stainless steel tanks.

The chrome-pickle coatings show the interesting visual property of a whole range of colors from matte, gray to yellow-red iridescence having a pebbled etch under the microscope, bright red tints with green shades, bright brassy colored surfaces that are comparatively smooth when viewed under the microscope, to bright silvery coatings. These color ranges are functions of the "worked" age of the bath and the nitric acid content. Brassy and silvery coatings result from increased nitric acid and the duller, less colorful coatings appear with newly prepared baths. Table III compares practical qualities of the variously colored chrome-pickle coatings.

The chrome-pickle coatings also have low electrical resistance and can therefore be applied on mating surfaces of machined parts that conduct electricity.

The chrome-pickle treatment offers considerable protection in normal inland or excessively humid atmospheres. However, in salt water or salt spray environments, chrome-nickel coating of magnesium without painting is not recommended. Dichromate is the preferred final treatment for magnesium alloys where maximum salt water corrosion resistance or a highly corrosion resistant paint base is desired. In this treatment the articles after proper cleaning are immersed for 5 min in an aqueous solution of hydrofluoric acid (15-20 percent by weight) maintained at room temperature and contained in a lead lined tank. After rinsing, they are immersed in a boiling solution of sodium dichromate (10-15 percent by weight) for 45 min. The coating formed is a rich velvety dark brown or black. Despite the long processing time, advantages of the treatment are:

1. It affords the most salt water corrosion resistance of any of the chromate or dichromate treatments for magnesium and its alloys.

2. It provides a good corrosion re-

sistant paint base for magnesium and its alloys.

3. Negligible dimensional changes result from this treatment, making it valuable for finish-machined parts.

4. Inserts of brass, bronze, and steel are not corroded by the treatment, but aluminum portions and cadmium plate are attacked by the hydrofluoric acid solution.

5. The process is easily operated and does not require electrical current.

The "Modified Alkaline Dichromate" treatment is almost as resistant to salt water corrosion as the dichromate treatment and forms a coating that is harder and more abrasion resistant. After 5 min in hydrofluoric acid, the pieces are dipped for 45 min in a boiling solution of:

Amonium sulfate	4 oz
Sodium dichromate	4 oz
Ammonia (sp. gr. 0.88)	1/3 fl. oz
Water	to make 1 gal.

This is followed by a 5 min dip in a boiling solution of arsenious oxide (1 percent by weight). The coating produced ranges from dark gray to black in color and there are no significant dimensional changes. It has essentially the same advantages that apply to the Dichromate treatment. However the solution used is somewhat more complex, and an additional process step is required.

There are available processes for treating magnesium which form absorbent coatings suitable as mordants for dyes. In these processes the magnesium surface is first converted to the hydrated oxide, after which the articles are immersed in suitable dyes. The resulting colors are rich and porcelain-like in texture. The processes are simple and relatively inexpensive; one such method merely involves heating the articles in water at 85 to 100 C and then dyeing. Single step processes use a water soluble dye in the solution.

More effective than the chemical conversion coatings, for corrosion protection and abrasion resistance of magnesium alloys, is an electrochemical method known commercially as the "Manodyze" process. Producing a protective and decorative magnesium-oxide-silicate film, it is applied by anodizing in strongly alkaline solution at elevated temperatures, using a-c or d-c. Although these coatings have somewhat higher corrosion resistance and far more abrasion resistance than those produced by the dichromate process, electrical equipment and accessories make the cost higher.

Magnesium can be electroplated commercially, yielding coatings with excellent adhesion. After suitable polishing, cleaning, and pickling, the magnesium parts are immersed in a fluoride-bearing zincate solution, and then copper plated in a cyanide copper plating bath. Then any other desired metal can be plated by normal procedures. Magnesium is plated primarily for sales appeal and attractiveness, which demand highly polished metallic finishes.

Corrosion resistance can be achieved by heavy plates, but this is more expensive than the chemical treatments. When extremely high corrosion resistance is required, the heaviest plate is not as effective as a good chemical treatment, followed by one or two coats of zinc chromate primer, and one or two coats of a baked glyceral phthalate base synthetic. If specialized property combinations, such as lightness with wear resistance or hardness are required, nickel, chromium, or nickel plus chromium coatings can be plated.

Aluminum and Its Alloys

For most indoor and many outdoor applications, little or no special corrosion protection is necessary to preserve aluminum, since a thin, firmly adherent, "self healing" oxide coating forms over its surface. However, in highly humid or saline atmospheres, additional protection is required for maximum service life.

Table III—Color and Quality Of Chrome-Pickle Coatings On Magnesium

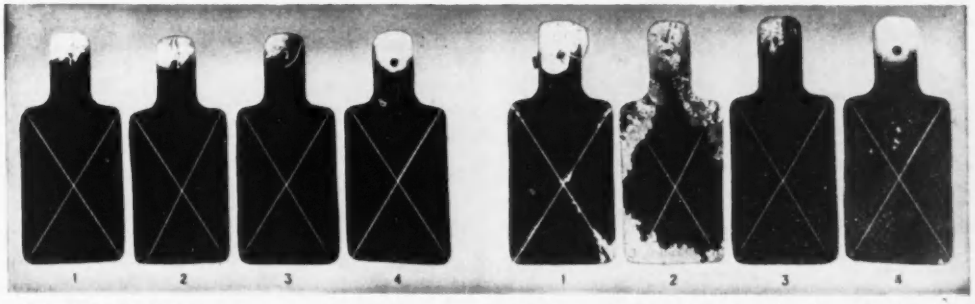
Color	Quality*
Matte gray	Less corrosion resistance than colored coatings. Good paint base.
Yellow-red iridescent	Good corrosion resistance. Very good paint base. Best all around coating.
Smooth brassy coating	Best corrosion resistance of all coatings. Poor paint base.
Silvery coatings	Poor corrosion resistance. Poor paint base.

* The words "good, poor, best" refer to other chrome-pickel coatings, not other types of chemically produced coatings.

From "Protective Treatments for Magnesium Alloys," *Metals and Alloys*, Feb. 1945.

Electroplating aluminum purely for corrosion protection is not recommended, unless heavy pore-free deposits are applied; such deposits are not economical for corrosion protection alone. As for magnesium, the most widely used inorganic protective coatings for aluminum are the oxidized or surface conversion coatings. The two types of coating used for this purpose are electrolytically applied coatings, derived from processes known as anodizing, and chemical immersion coatings, the best known of which are the Aluminum Company of America's "Alrok" coatings.

For maximum corrosion resistance, the anodized aluminum films are best. Three anodizing processes are in general use: Chromic acid, sulfuric acid, and oxalic acid. The first two are most widely used in the United States; the sulfuric acid process is patented by the



ADVANTAGES of dichromate treatment are illustrated by corrosion tests of these magnesium alloy pieces. Left, before corrosion testing: Samples 1 and 3 dichromate treated and painted, samples 2 and 4 untreated and unpainted. Right, after testing: Samples 1 and 2 salt spray tested for 120 hr, samples 3 and 4 constant humidity tested for 120 hours.

Table IV—Economy vs Utility of Inorganic Coatings on Aluminum

Coating or Finish	Use	Relative Economy and Utility
Caustic Etch	Attractive white satin finish	No added corrosion resistance, most economical coating to apply; for decorative purposes.
Alrok	Corrosion resistance or paint base	Not as corrosion resistant as anodized coatings. More economical to apply than anodizing. Can be applied on small parts in bulk.
Anodizing (chromic acid)	Corrosion resistance Paint Base	High corrosion resistance. Economical. Not to be used on alloys of copper content more than 5 percent.
Anodizing (sulfuric acid)	Corrosion resistance Paint Base Dye Mordant	High corrosion resistance. Economical. Can be dyed, with beautiful fast colors resulting.
Phosphate	Paint Base	Inexpensive treatment where aluminum is to be finished with organic coatings.
Plating	Decorative or specific of finally deposited metal	More expensive than other processes but frequently required for sales appeal or other specific application. Heavy plating for corrosion resistance generally not warranted from an economy point of view.
Immersion Tin Plating	Prevention of seizing galling, scuffing	Inexpensive process where this specific property is required.

Aluminum Company of America under the name of "Alumilite." For aluminum alloys with a copper content not more than 5 percent the chromic acid process is satisfactory. In this method, the work is the anode for 30 min. or more in a 5 to 10 percent (by weight) solution of chromic acid in water, at about 40 volts; this is considerably higher than the voltages used in most electrochemical processes. The coating is thin but dense, gray and dullish.

If the copper content of the alloy is more than 5 percent, the sulphuric acid process should be used. The coating is formed by making the work the anode in a 10 to 20 percent solution of sulphuric acid in water. The coating, thicker and more abrasion resistant than that formed in the chromic acid process, is absorbent and is usually "sealed" in hot water or sodium dichromate. The "unsealed" coating does not change the color of the surface, but the coating "sealed" in sodium dichromate imparts a yellow greenish cast to the surface. The sulfuric acid process is especially useful if a colored aluminum surface is required; the anodized coating acts as a mordant for dyes, allowing a wide range of colors to be produced. The aluminum parts are immersed in the desired dye solution and then "sealed" in hot nickel solutions.

The Alrok coatings increase corrosion resistance of aluminum alloys, but not to the same extent as anodized coatings. They are applied by immersing the work in hot sodium chromate and sodium carbonate solutions, then in a dichromate solution, until a gray colored coating is formed.

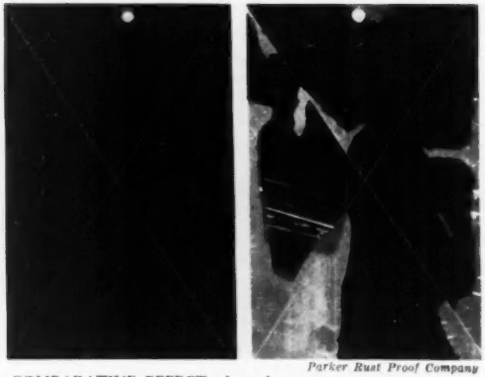
An inexpensive method for giving aluminum a frosty white satin finish, where corrosion resistance is not primary, is called "caustic etching." It consists of immersion in an alkaline solution, such as trisodium phosphate or caustic soda, etching the work until the desired texture—bright or more deeply etched satin—is obtained. This is followed by a dip in 50 percent nitric acid. The resulting finish is white and uniform, even obliterating many surface defects and scratches.

Aluminum can be plated on a commercial basis, competitive with other finishing methods. If correctly applied the plates are adherent and have the same decorative and specialized utility as on other metals. The process consists of: Polishing or buffing, degreasing, pickling, depositing on the aluminum surface a thin film of zinc from a sodium zincate bath, copper plating, and then conventional plating.

Aluminum surfaces can be immersion plated with a thin film of tin from a stannate solution. The tin plated aluminum surface performs better than unplated aluminum where seizing, galling, or scuffing resistance is desired. Many aluminum alloys have been hard chrome plated directly, one application being the preparation of a hard scratch free reflecting surface produced by lapping flat several thousandths of hard chromium plated directly upon aluminum.

EDITOR'S NOTE: The concluding article of this series will be presented in October PRODUCT ENGINEERING.

ALUMINUM ALLOY HOUSINGS after salt spray test. Before test, housing on left was anodized and painted, housing on right was painted without first anodizing.



Parker Rust Proof Company

COMPARATIVE EFFECT of outdoor exposure for 3 months. Aluminum sheet panel at left is phosphate coated (Bonderized) and painted. Panel at right is painted without phosphate coating.

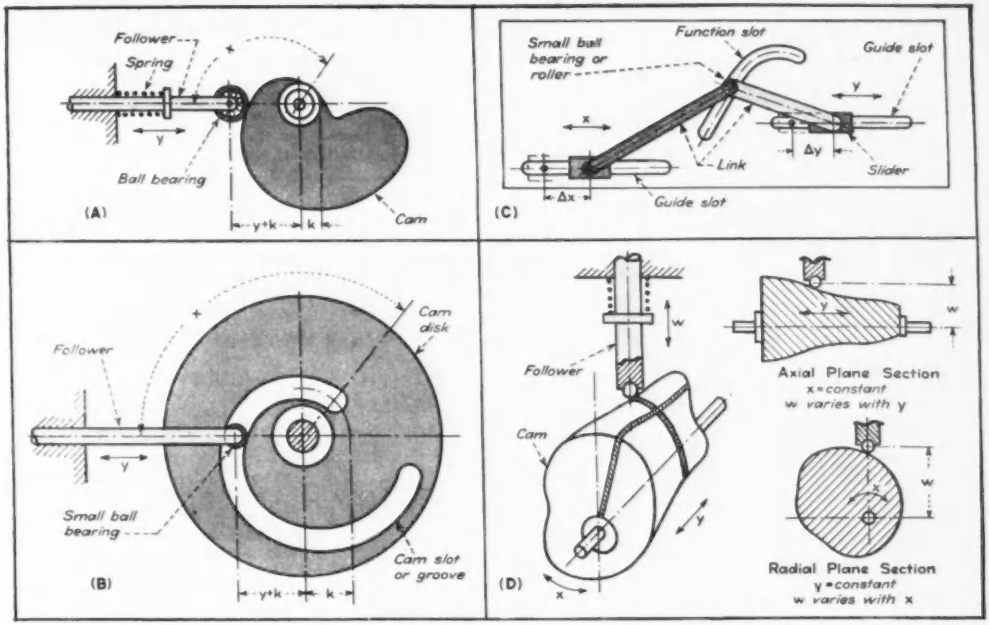


Fig. 4—Some cam mechanisms for function generation: (A) Rotary plate cam; (B) Rotary groove cam, which avoids spring loading the mechanism; (C) Function slot cam, which is frequently useful; (D) Three-dimensional cam, for two variables.

Mechanical Computing Mechanisms—II

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Initial considerations in the design of mechanical analog computers were explained in last month's article. This installment begins the analyses of individual mechanisms for function generation, including trigonometric functions. Also, four mechanisms for adding and subtracting two variables are described.

Generation of Functions

A function generator may be considered the simplest form of computer, since it actually mechanizes an equation. Some of the mechanisms to be described use functions of variables to perform the computation.

A functional relationship,

$$y = f(x)$$

which involves no discontinuities, may be established between any two variables (x) and (y) by using some form of cam mechanism. Certain trigonometric functions, such as

$$y = \sin x$$

may be obtained from devices that mechanize the geometry of the trigonometric relationships. A type of cam mechanism using both rotary and translatory motion (two degrees of freedom) may be used to obtain the relation

$$w = f(x, y)$$

Cams with a single degree of freedom are commonplace in designs of gasoline engines and automatic machinery. The type most commonly employed is the simple rotary plate cam; cylindrical and radial groove cams are often used, and occasionally a translatory or slide cam finds application. Each of these types is used in computer design to mechanize the relation

$$y = f(x)$$

in which $f(x)$ may be a series of values in tabular form, or a mathematical expression in powers of (x). In a sense, the surface of the cam may be considered a "mechanical graph" of the function expressed in polar coordinates for rotary cams and in rectangular coordinates for the slide types. This conception must be modified, of course, to account for the finite sizes of hubs, shafts and cam followers.

Each cam mechanism requires a follower, the motion of which is proportional to the generated function. In computers and instruments, which

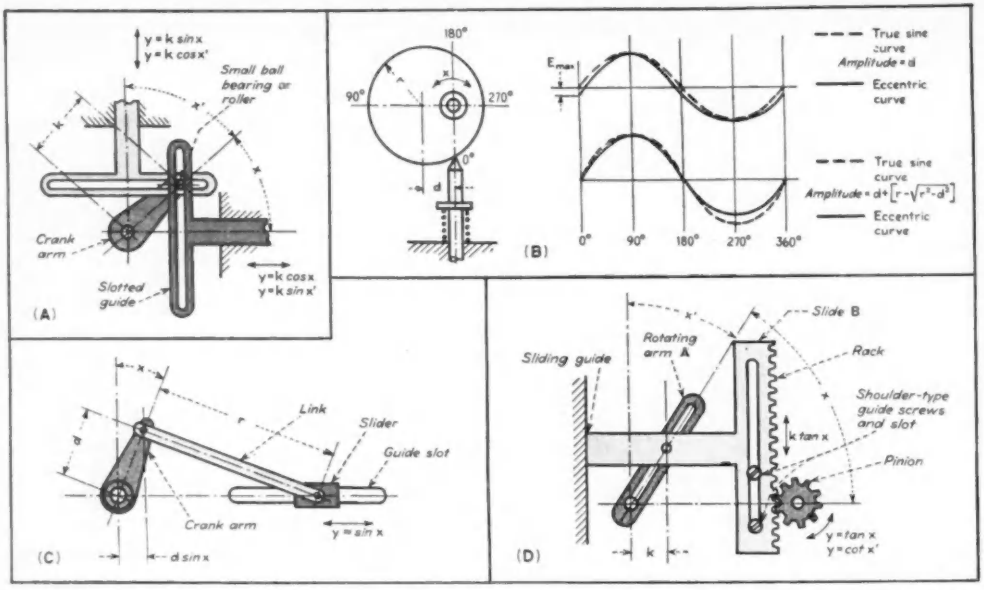

Fig. 5—Mechanisms for reproducing trigonometric functions: (A) Scotch yoke for sine-cosine relationships; (B) Eccentric, (C) Crank mechanism, for approximating sine-cosine functions; (D) Tangent-cotangent mechanism, approximate only.

must operate at a low friction level, ball-bearing followers are the most satisfactory. The motion of the follower is constrained by suitable guides to either rotary or translatory motion.

The same principles apply to rotary computing cam design as to ordinary cam design, in regard to undercutting, maximum pressure angle and compensation for rotary follower motion. An originally sliding input motion is often converted into a rotation, by means of a gear and rack, so as to make use of a rotary cam, which is easy to design and fabricate.

The relations of the mathematical quantities and physical displacements for rotary cams are shown in Fig. 4(*A*). The cam rotation from some initial position represents the independent variable (x); the follower radius (defined for ball-bearing or roller followers as the distance from center of cam shaft to center line of follower) at this point, which determines the position of the follower, is y plus a constant k equal to the minimum cam radius. This constant is eliminated by offsetting the y scale, so the relation

$$y = f(x)$$

is satisfied by the mechanism.

Simple plate cams require a spring to insure contact between the cam periphery and the follower regardless of direction of rotation. Radial groove cams, Fig. 4(*B*), are considerably harder to fabricate, but the elimination of the spring load on the mechanism often justifies using this type.

A very useful slide cam, is the cam slot, Fig. 4(*C*), consisting of a function slot milled into a plate, designed empirically in such a way that a point on the independent variable slide proportional to x corresponds to a point of the y slide designated $f(x)$. The design of these devices consists largely of layout work in which each configuration is tested for self-locking conditions. A good rule-of-thumb for avoiding a self-locked mechanism requires that Δx be always larger than the corresponding Δy.

A functional relationship is established between two variables by a "three-dimensional" or barrel cam, Fig. 4(*D*). Here the cam is rotated by the x input and simultaneously and independently translated axially by the y input. These actions position the follower at a point.

$$w = f(x, y)$$

Theoretically a point follower is correct for this type of cam, but such a follower may be used only with very light loading, and the point tends to wear quickly. A ball-point follower is preferable.

Designing three dimensional cams is quite laborious. The procedure is to consider laminar sections as simple plate cams, varying w with x and holding y constant, as shown in the diagram Fig. 4(*D*). It is also necessary to consider radial plane contours in which w varies with y as x remains constant. Each radial and axial section must be checked separately for such undesirable cam characteristics as excessive pressure angle or undercutting. These difficulties may be minimized by increasing the minimum cam radius, with the added disadvantage of a larger cam. The fabrication of such a three-dimensional cam is also quite difficult. The usual method follows the laminar design plan in which successive flat plate cams are fastened together and the edges blended by filing.

Trigonometric Functions

The continuous trigonometric functions

$$y = \sin x \text{ and } y = \cos x$$

may be generated over any portion of the entire range of x from 0 to 360 deg, with any type of cam described, Fig. 5; or a number of geometric devices may be employed to mechanize these functions.

THE SCOTCH YOKE. This familiar mechanism causes exact, simple harmonic motion of the follower slide,

and so produces an output function

$$y = f(x) = k \sin x$$
$$y = f(x) = k \cos x$$

depending on the choice of the axis representing the zero value of the angle. The radius, k, of the rotating arm determines the scale factor of the device. Two Scotch yokes at right angles, as in Fig. 5(A), will produce simultaneously as two perpendicular motions, sine and cosine functions of the same angular input variable.

THE ECCENTRIC. An eccentric with a follower constrained to straight-line motion is an excellent device for approximating sine and cosine functions, since it requires a few easily machined parts, and a minimum of space. Considering such a mechanism as a circular cam of radius, r, with the center of rotation offset by an eccentricity d, the output is an approximte sine function of amplitude, d. Comparing this function with a true sine function of the same amplitude, as in Fig. 5(B), the maximum error is

$$\epsilon_{max} = r - \sqrt{r^2 - d^2}$$

which occurs at 0 deg and 180 deg, the output being correct at 90 deg and 270 deg. However, if the curve generated by the eccentric is raised an amount equal to

$$\frac{\epsilon_{max}}{2}$$

the error is split and the output is correct at four points; the maximum error is halved, and the curve is a good approximation over the full 360 deg range. This error-splitting scheme is useful in designing approximate computing mechanisms. As a result, with an r/d ratio of 20:1 the maximum error is $1\frac{1}{4}$ percent of d.

Using a true sine function of amplitude,

$$d + [r - \sqrt{r^2 - d^2}\,]$$

as a basis of comparison, a much closer approximation is obtainable between 0 deg and 180 deg, but the fit is poor between 180 deg and 360 deg, the maximum error being

$$\epsilon_{max} = 2\,[r - \sqrt{r^2 - d^2}\,]$$

It is apparent that, if the location of the follower is rotated 90 deg, the device will produce an approximate cosine function with similar error characteristics.

CRANK MECHANISMS. Another approximate sine-cosine mechanism, working on a principle similar to the eccentric just described, is the crank mechanism pictured in Fig. 5(C). With a crank length, d, and a connecting link of length, r, the output is again a sine function of amplitude, d.

The error analysis for the crank is similar to that described for the eccentric where ϵ_{max} is also equal to the same expression, $r - \sqrt{r^2 - d^2}$. The same scheme of error splitting may be applied to the crank mechanism error. Shifting the axis of reference 90 deg will result in the generation of a cosine function.

The trigonometric functions

$$y = \tan x \text{ and } y = \cot x$$

are discontinuous at certain points in the range of x between 0 deg and 360 deg—at 90 deg and 270 deg in the case of the tangent function, and at 0 deg and 180 deg in the case of the cotangent. There is, therefore, no geometric device nor any cam mechanism which will mechanize the full range of these functions. A cam designed to mechanize a portion of the range of the functions must have a very steep slope as it approaches the point of discontinuity. Cams that cover a considerable range, say 0 deg to 80 deg for the tangent, must have a large average radius and a very small total throw to keep the pressure angle within practical limits. The result is a small scale factor output.

The geometric device for tangent and cotangent mechanization, shown in Fig. 5(D), is similar to the Scotch yoke except that the pin is fixed in the output slide, B, and the rotating arm, A, is slotted. The displacement of B is

$$k \tan x$$

and the rotation of the pinion is

$$y = \tan x$$

This mechanism is limited by inherent self-locking to a range of approximately 30 deg of x. Note that, if the complementary angle (x') is considered the independent variable, the output is

$$y = \cot (x')$$

The secant and cosecant functions, which are reciprocals of the cosine and sine functions previously discussed, experience discontinuities similar to tangent and cotangent. The mechanizable portion of their range is best obtained by using cams.

A combination of function generator and multiplier shown in Fig. 6, is a device known as a resolver or component solver. It mechanizes the relations

$$x = w \cos \theta$$
$$y = w \sin \theta$$

If the vector length and angle are inputs, the mechanism is a component solver, and the outputs are the x and y components of the vector. Conversely, if the components are in-

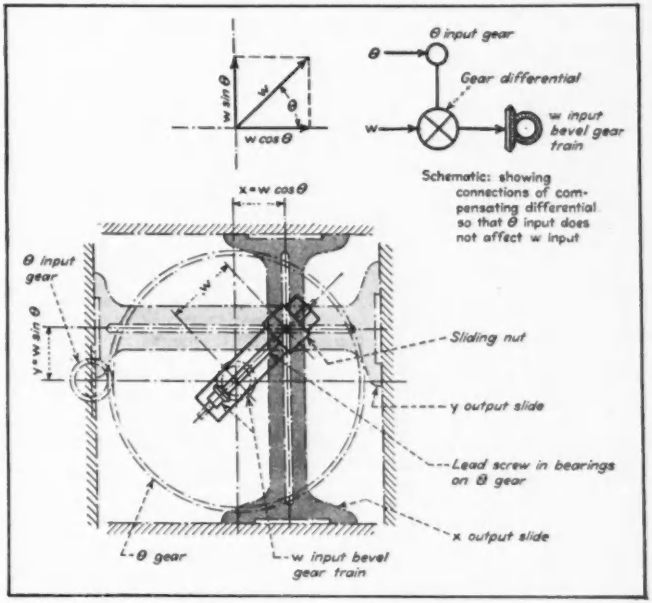
θ input gear
θ
Gear differential
w
w input bevel gear train
w sin θ
w cos θ
Schematic: showing connections of compensating differential so that θ input does not affect w input
x = w cos θ
θ input gear
y = w sin θ
Sliding nut
y output slide
Lead screw in bearings on θ gear
x output slide
θ gear
w input bevel gear train

Fig. 6—Component solver, for resolving a vector into x and y components, or for combining two components into a resultant.

puts, the resultant length and angle of the vector are outputs.

Addition and Subtraction Devices

Some form of differential mechanism is used universally for adding and subtracting two variables by mechanical means. Four of the most widely applicable types are: bevel gear, spur gear, link and slide. These devices solve the general equation

$$\frac{x \pm y}{2} = w$$

in which w is usually the output and x and y are the inputs. If desired, any two of these variables may be considered inputs, and the third as the output, where x, y, w refer to rotations as in Fig. 7(*A*) below.

Bevel gear differentials are adapted to rotary inputs. Generally the inputs are fed into the differential by spur gearing, attached to the bevel gears. The sum or difference of these inputs appears as the rotation of the spider.

It is convenient to consider the total w rotation as obtained in two steps. In the first step, gear 2 is held while gear 1 is turned through an angle x. Therefore, from the instantaneous velocity diagram, v_2, the velocity of point 0 on bevel gear 2, is zero, since gear 2 is held and this point is the instantaneous center of rotation (centro) of gear 3. It follows from the velocity diagram that r_3 is equal to $v_1/2$, from which it is apparent spider shaft 3 will turn through an angle $x/2$. In the second step, gear 1 is held at this new position, and gear 2 turned through an additional angle, y. From similar considerations, this causes a rotation of spider shaft 3 equal to $y/2$. The total rotation of the spider due to input rotations on gears 1 and 2 of x and y respectively is, therefore

$$w = \frac{x}{2} + \frac{y}{2} = \frac{x+y}{2}$$

If the spider shaft is held so that w equals 0, the rotation of the x input produces an equal rotation of the y

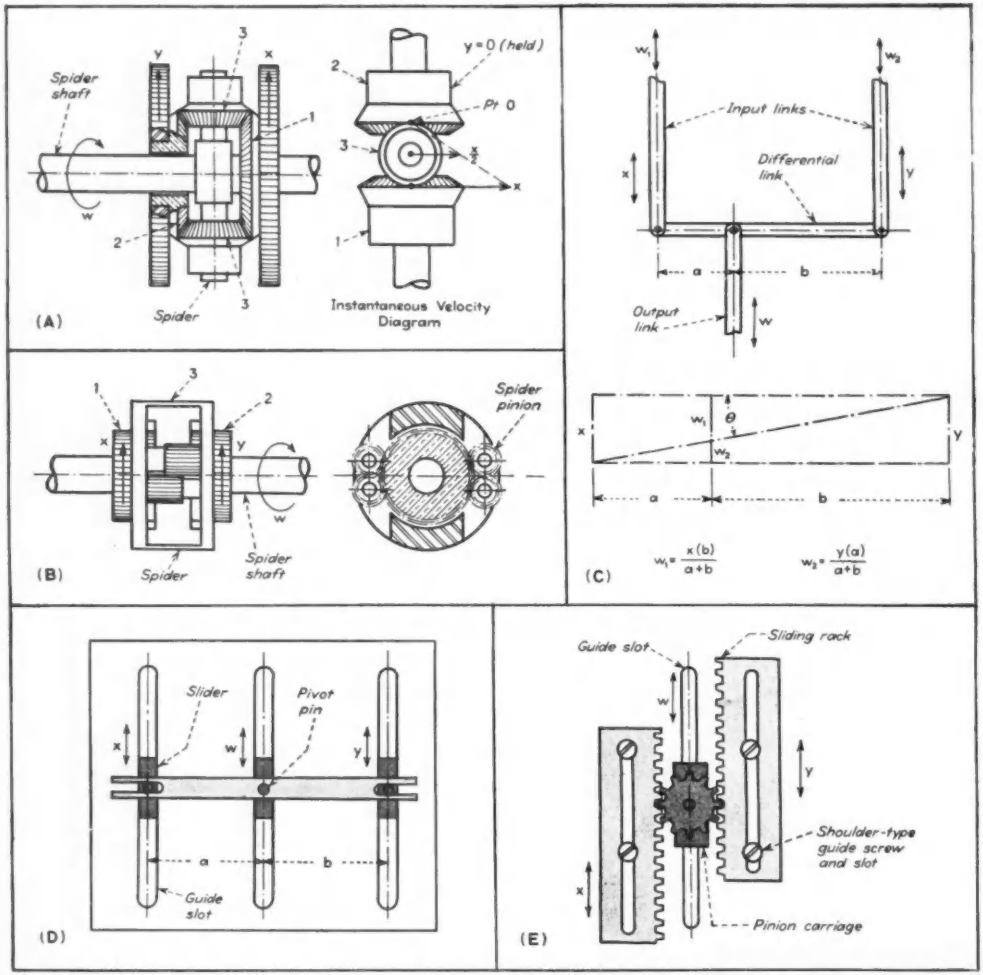

Fig. 7—Addition and subtraction mechanisms: (A) The bevel gear differential and its velocity diagram; (B) The spur gear differentials; (C) Link differential; (D) Slide-link differential; (E) Slide-pinion type of differential (no theoretical error).

gear, in an opposite direction, so that

$$x = -y$$

The constant, 2, appearing in the above equation is simply the diameter-radius ratio of gear 3. This constant is inherent in the type of construction in which gears 1 and 2 are of equal size. The size of gear 3 relative to 1 and 2 is immaterial, therefore, and may be chosen at will for particular applications.

A spur gear differential embodying the same characteristics is illustrated in Fig. 7(*B*). This spur gear differential solves the same equation:

$$\frac{x + y}{2} = w$$

The advantages of spur gear differentials over the bevel gear are compactness of design and fewer parts.

This mechanism is a special case of planetary gearing, and may be constructed in several ways. Again, the relative size of input gears and spider pinions is independent of the output ratio, as indicated in the equation. Fig. 7(*B*) shows a differential with two pairs of spider pinions. If heavy loads are anticipated, the number of pairs may be increased to decrease gear tooth loading.

The link type of differential, Fig. 7(*C*), is another adding or subtracting mechanism where

$$w = \frac{x\,(b) + y\,(a)}{a + b}$$

or, if $a = b$, $w = \frac{x}{2} + \frac{y}{2}$ as before.

Considering the motion of the output w to be composed of two separate components, w_1 due to input x, and w_2 due to input y, then

$$w_1 = \frac{x\,(b)}{a + b}$$

$$w_2 = \frac{y\,(a)}{a + b}$$

on the principles of similar triangles. It follows that

$$w = w_1 + w_2 = \frac{x\,(b)}{a + b} + \frac{y\,(a)}{a + b} = \frac{x\,(b) + y\,(a)}{a + b}$$

As drawn in the schematic form in Fig. 7(*C*), this addition mechanism is an approximate device. The degree of approximation is governed by the limit on the angle θ, determined by the total range of the variables x and y and the length of the differential link $(a + b)$. This follows from the fact that the analysis assumes the x, y and w motions are straight lines, when actually they follow circular paths about moving centers. Since the projected length of a and b along a perpendicular to the input direction equal the actual length of a and b to the desired degree of approximation, the mechanism is large in comparison to a gear type of differential, with a small allowable input and output motion.

Fig. 7 (*D*) shows a more complicated slide-link differential which has no Class B (theoretical) error. Three parallel guides direct the variable motions. The connecting link is pivoted on the w slide, and makes sliding pin-and-slot connections with the x and y input slides.

Another type of slide differential, constructed to eliminate Class B errors, is pictured in Fig. 7(*E*). The pinion meshes with both racks, and rotates about a fixed stud in the w slider. Once again

$$w = \frac{x + y}{2}$$

All these mechanisms also may be used as subtractors when used to add negative numbers.

The Class A errors to be minimized in geared differential mechanisms are (1) backlash, (2) inaccurately cut gears, and (3) incorrectly mounted gears. Precision gears and close tolerances on center distances will minimize these undesirable conditions. If backlash is unavoidable, a take-up spring may be used to keep backlash always in the same direction. But such a spring must be capable of driving the whole gear train on which it operates, so that the forces between teeth are always in one direction regardless of the direction of rotation. A spring sufficiently powerful to accomplish this usually imposes large forces on the computer mechanisms.

Class A errors in slide and link mechanisms arise from lost motion in slides and pin slots. High accuracy in machining parts is the chief remedy.

EDITOR'S NOTE: Next month mechanisms for multiplication, division, integration and differentiation will be discussed.

Gyroscope Redesign Will Aid Missile Research

A "non-precessable" gyroscope has recently been perfected by Charles Stark Draper, professor of aeronautical engineering at the Massachusetts Institute of Technology. To date, little information has been released as to the design details, but the impact on guided missile development can be realized.

In order to understand what the new gyroscope is and means, the primary problem of guided missile design must be considered. This problem is the design of an accurate and dependable guiding mechanism that will provide stability. This characteristic is built into all missiles in the form of gyroscopes that gage any mistaken tendency to soar, slip or veer and correct the missile's error electronically. But gyroscopes themselves have always, hitherto, been subject to error. Friction in their bearings gradually alters their settings causing precessing. Thus the very commands that these guardians give their missiles begin to be seriously incorrect.

Professor Draper's new gyroscope is not absolutely free of precession. It is simply sufficiently accurate so that it may be depended upon for a considerable period as gaged by the lightning-like standards of guided missile experimenters. In short, it will keep a missile stable for the few minutes needed to complete an intercontinental trajectory, which is, after all, enough.

How this has been accomplished is not precisely known. But it is thought probable that Draper has turned the trick by incredibly accurate machining.

If the hard steel and agate of a bearing are machined and polished until no single molecule protrudes beyond its neighbors, then friction is eliminated for practical purposes. By this kind of polishing, which has been used on the lenses of the big California telescopes, Draper could have made his almost frictionless bearing and his non-precessable mechanism.

The new gyroscope is most emphatically in the early experimental stage. In combination with an eighteen-inch ram jet already developed and being flown by the Navy, the device holds out the possibility of a radical shift of advantage from the attacker in the air to the defender in the air. The gyroscope alone holds out the further possibility of subsequent reversal of this shift in the opposite direction, when long-range guided missiles are finally perfected.

Hydraulic Chucking Devices

INTERNAL HYDRAULIC CHUCKING

Hydraulic fluid enters rotating cylinder when directional hydraulic control valve is shifted. Rotating cylinder piston then pushes on bell crank of chuck through drawrod. False jaws operated by bell crank then grip work. To release grip, drawrod is pulled back when control valve lever is reversed.

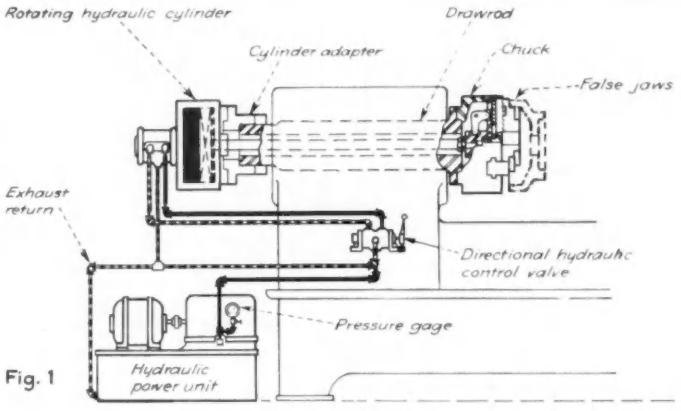

Fig. 1

EXTERNAL HYDRAULIC CHUCKING

After operation of directional hydraulic control valve, pull on bell crank through drawrod closes false jaws on work. Upon reversal of control valve, jaws are opened and work is released. Hydraulic accumulator in power unit maintains pressure for relatively long periods of chuck operation.

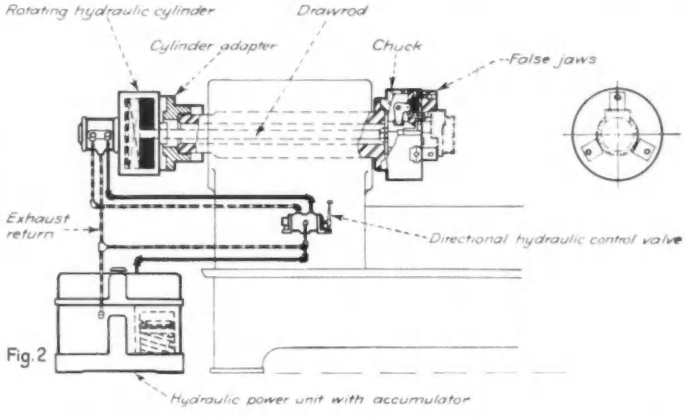

Fig. 2

HYDRAULIC CHUCK AND TAILSTOCK

After operation of directional hydraulic control valve, fluid enters non-rotating cylinder, and tailstock moves into position, and sequence valve *A* opens. Hydraulic fluid then admitted to rotating cylinder causes mandrel to grip work. When machine operation is completed, control valve is reversed. Tailstock retracts and sequence valve *B* opens, causing mandrel to release work.

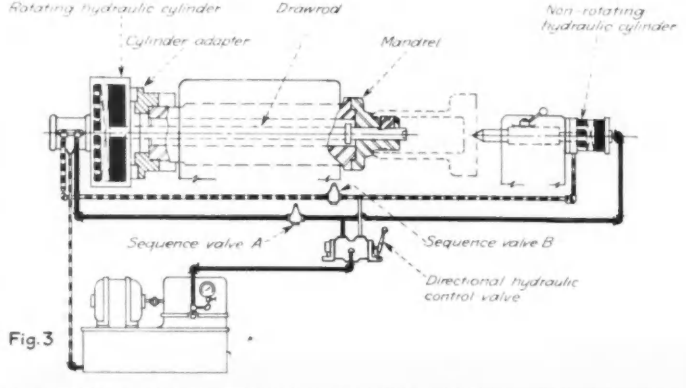

Fig. 3

for Lathe Applications

HARRY L. STEWART
Logansport Machine Company, Inc.

HYDRAULIC CHUCK AND FEED

After directional control valve is shifted, mandrel grips work. Push button operated solenoid valve admits hydraulic fluid to tool feed cylinder at a rate regulated by flow control valve. Completion of tool travel trips limit switch reversing solenoid valve. Tool then returns to original position. Reversing directional control valve then causes mandrel to release work.

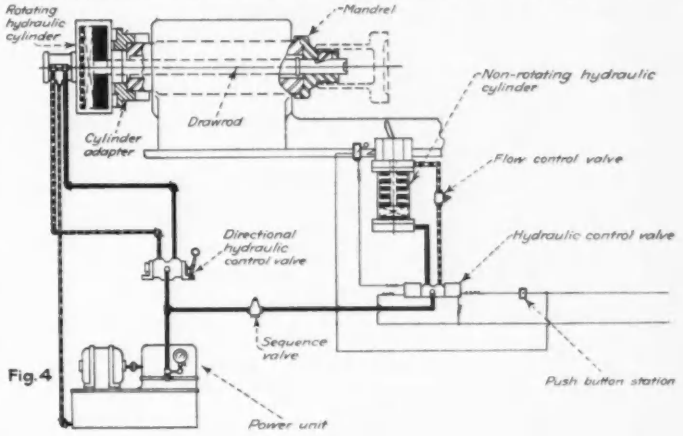

Fig. 4

HYDRAULIC CHUCK AND AUTOMATIC FEED

Shifting hand operated hydraulic pilot valve causes push type mandrels to grip work. Gripping work automatically trips sequence valve, opening control valve for non-rotating hydraulic cylinder. Tool is then fed hydraulically until hydraulic pilot valve is tripped. This reverses righthand control valve to return tool feed cylinder. Shifting hand operated pilot valve releases work.

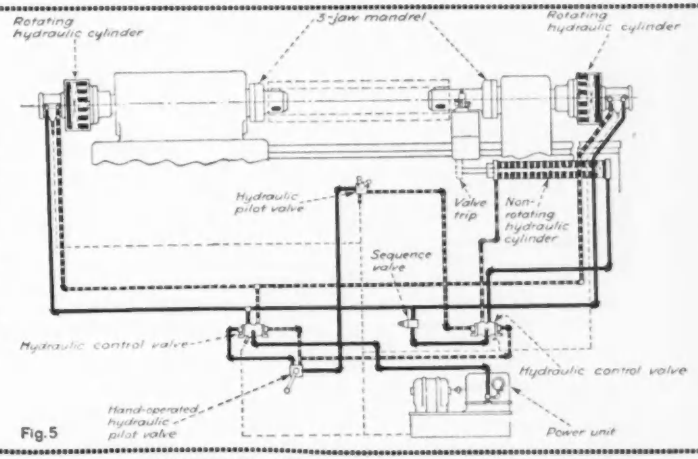

Fig. 5

HYDRAULIC CHUCK WITH ELECTRIC CONTROLS

Electric controls replace the pilot valves shown in Fig. 5. Pressing push button causes mandrels to grip work. This trips the pressure switch causing non-rotating hydraulic cylinder to feed cylinder. At the end of the tool travel, tripping the left hand limit switch returns tool to original position. This trips righthand limit switch, which initiates release of work.

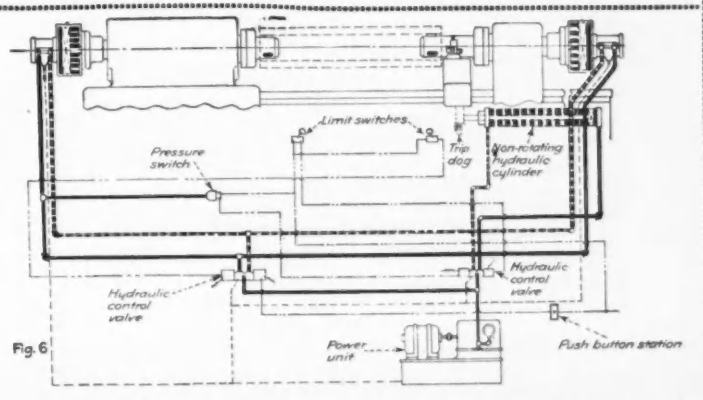

Fig. 6

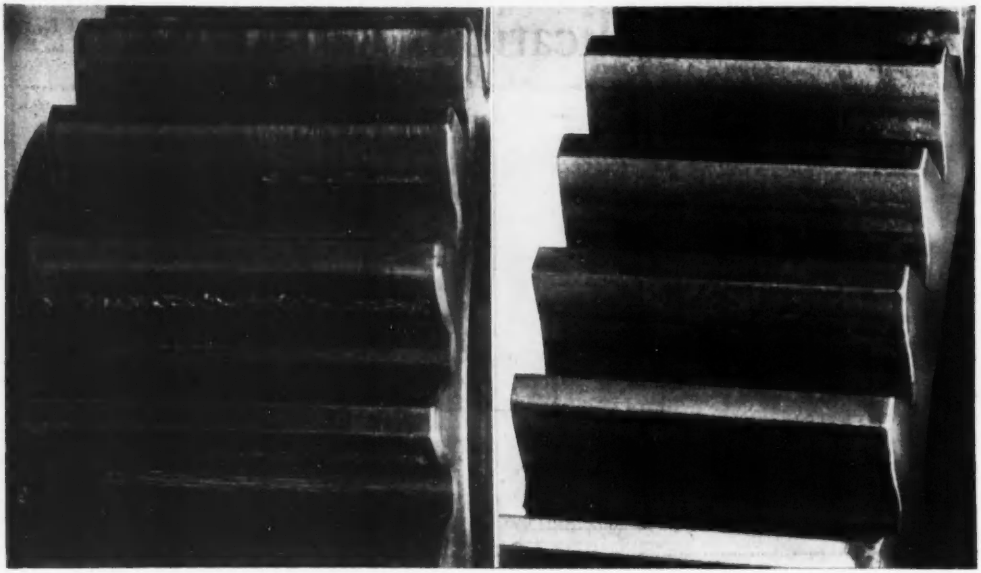

Fig. 1—Wear on gear and pinion having unmodified tooth profiles. Although the teeth were accurately hardened and shaved, failure occurred after a few million cycles of operation. Such tooth failure can frequently be corrected by profile modification.

Modification of Gear Tooth

Recommended method of changing the involute profiles of heavily loaded gears to reduce noise, interference, and wear.

D. W. DUDLEY
Gear Engineering Division
General Electric Company

WHEN GEARS are operated under severe torque loads, there are frequently signs of distress on the tooth faces. Under moderate load, the gears will usually operate for long periods of time with no measurable wear. As the load is gradually increased, the first signs of wear frequently occur at the first point of contact. This wear resembles mild scuffing or etching, and can only be detected by a trained eye. The rate of wear may be as slow as 0.0002 in. per million cycles, which, although apparently small, may be dangerous and deadly if the gears are designed for several hundred million cycles or more.

A further increase of load on the set will often cause a second region of wear to begin at the last point of contact. This progresses slowly and requires sensitive measuring machines or a keen eye to detect it in the first few million cycles. A still further increase in load often causes pitting to start in the region of the pitch line of the driver and sometimes on both members; frequently scuffing and galling also occur at about the same load.

If a gear set that is loaded heavily enough to cause wear at the first point of contact is operated for a prolonged period of time, the gradual wearing away of the tooth profile will ultimately cause the gear to lose its smooth involute action; finally, the pitch line region will be overloaded and subject to shock loads which will break it down. As a general rule it can be said that unchecked wear at any point on the tooth profile will ultimately cause tooth failure.

A set of gears that were tested under heavy load with accurately shaved and hardened teeth but with no tooth profile modification is shown in Fig. 1. The destructive wear at the tips and roots of the teeth is clearly visible. In the region of the gear pitch line there is no wear, but in the region of the pinion pitch line the final destructive pitting-type of wear has begun.

Such signs of wear often are an indication that greater load carrying capacity and longer life can be obtained by modification of the tooth profiles. In general, profile modifications are made (1) to minimize probable tooth spacing errors; and (2) to eliminate tooth interference due to deflection under heavy load.

Change in Pressure Angle

When spacing errors are present in gear teeth, some teeth are spaced too close together and others too far apart. Suppose one pair of teeth are in contact and a second pair are just ready to start making contact. If the two teeth on the driver are too close together or the two teeth on the driven gear are too far apart, the second pair of teeth will make contact prematurely and there will be a certain amount of shock and noise as they contact. Errors in profile also cause occasional pairs of teeth to enter mesh with a shock.

It has been found by experience that gears can be made to run more quietly by making the involute curve of the driver slightly plus or the involute of the driven gear slightly negative. As indicated in Fig. 2 (A) true involute curves provide no clearance at the first point of contact. The tooth action is

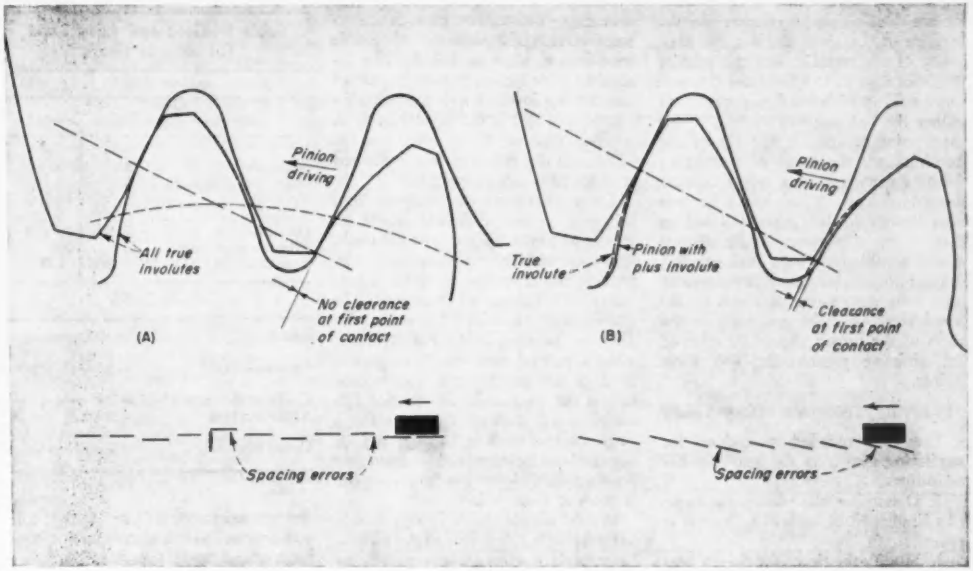

Fig. 2—Effect of spacing errors with true involute profile (A), and with modified involute profile, (B). In (A), there is no clearance at the first point of contact. Clearance obtained at (B) by pressure angle modification minimizes tooth spacing errors.

Profiles

somewhat analagoues to sliding a brick over a cobblestone street. If the driving pinion has a slightly plus involute, there is clearance at the first point of contact. The tooth action in this case is similar to sliding a brick down a shingled roof. Therefore, it is reasonable to expect quieter and smoother running gears with a small amount of pressure angle modification in the right direction than with a true involute profile.

The amount of pressure angle modification for best results depends on the magnitude of errors as well as the speed and load conditions under which the set is expected to operate. For instance, if spacing errors are on the order of 0.0005 in. tooth to tooth, and profile errors are also about 0.0005 in., it is reasonable to start testing gears with a total profile modification in the range of 0.0005 to 0.001 in. Actual test experience then will indicate whether to slightly increase or reduce the amount of this modification.

Tip and Root Relief

Even if there are no errors in spacing or profile on gears that are operated under heavy load, the deflection of the teeth may cause a second pair of teeth to enter mesh too soon. This is particularly damaging under heavy load conditions because of the peculiar action of a tooth entering mesh.

The path of motion of a gear tooth tip as it enters mesh when the pinion is driving is shown in Fig. 3. The gear tooth tip actually follows a path of motion that tends to cut metal off the pinion. Under heavy load, there is tooth deflection, and the gear tip does not come into mesh just tangent to the pinion profile. Instead it tends to cut a chip of metal off the pinion.

Or first thought it would appear that the logical modification to overcome the tendency for cutting at the first point of contact would be to use a pressure angle modification. This remedy is not much good, however, because a pressure angle change to relieve the first point of contact puts additional load on the last point of contact.

This is indicated in Fig. 4, which shows in a exaggerated manner a comparison between the load conditions at the pitch line of a pair of gears and

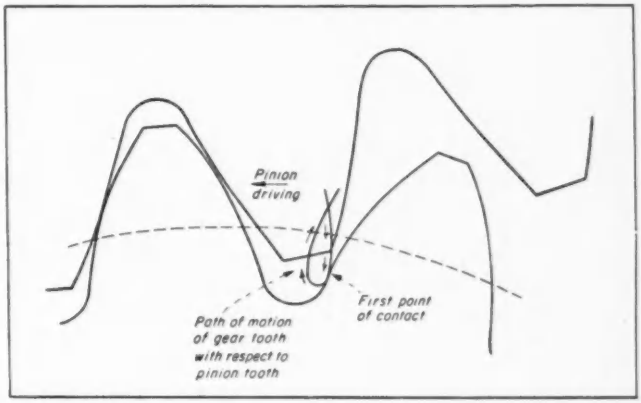

Fig. 3—Path of motion of a gear tooth tip as it enters mesh (pinion driving). Tooth of the gear has a cutting motion with respect to the flank of the pinion.

at the last point of contact. In the middle of the tooth profiles, the elasticity of the metal causes the profiles to deform so as to spread the pressure over a fairly wide band af contact. At either the last point of contact or the first point of contact, the tip of the tooth causes the band of contact to become narrow with a severe concentration of load. Thus, it can be seen that heavily loaded gears will not be helped by a pressure angle change which would protect the first point of contact but overload another vulnerable spot—the last point of contact. Instead, the tips of the gear teeth or the roots of the pinion should be relieved to minimize pressure at both these points.

Modifying Teeth for Heavy Loads

The recommended procedure for modifying gear teeth for heavy load is as follows:

1. Determine the deflection curve of a single pair of teeth as accurately as possible.
2. Modify the tip of the driven gear tooth or the root of the driving pinion tooth so that little or no load is carried at the first point of contact.
3. Modify the pinion tip or the gear root so that a high load is not carried at different points of contact.
4. Make the shape of the modifications such that reasonably uniform angular velocity is obtained at the most critical operating load.
5. After the best theoretical design has been worked out on paper, make actual tests of the gears to see if the original modifications should be slightly increased or decreased.

Determining the actual deflection characteristics of heavily loaded gears is necessary because it is on such characteristics that the amount of profile modification must be based. The results of a deflection test on a pair of true 20 deg involute spur gears having a ratio of 4 to 1 is shown in Fig. 5. A constant load of 5,000 lb-in. was applied, and the deflection was measured at different points of contact.

Every other tooth was removed from the gear so that deflection could be measured for a single pair of teeth. Then calculations were made to determine the deflection curve for a gear and pinion having all their teeth. In this example, the base pitch was equivalent to 18 degs roll. For instance, when a pair of teeth was in contact at 10 degs roll, another pair was in contact at 28 degs roll. By proper calculation, the stiffness constants for a single pair of teeth at 10 degs and 28 degs roll can be combined to determine the combined deflection for two pairs of teeth at these points.

In the example shown in Fig. 5, contact starts at 5.5 degs roll of the pinion. Since tooth contacts are separated by an 18 deg interval, a second pair of teeth would be in contact at 23.5 degs. (18 deg + 5.5 deg). When contact on one pair of teeth reaches 15 deg, contact ends on the second pair of teeth since they reach the last point of contact at 33 degs. (15 deg + 18 deg.) In the region between 15 degs and 23 degs only one pair of teeth can be in contact. In Fig. 5 this region is shown as the, "zone of single tooth contact."

Once the deflection curves have been calculated, or determined by test, it is possible to plot the percent load carried by a pair of teeth as it rolls through mesh. Suppose one pair of teeth have just started to contact at 5.5 degs roll and a second pair is in contact one base pitch ahead at 23.5 degs roll.

Table I—Gear and Load Data for Sample Gears

Gear Data		
Dimension	Pinion	Gear
No. teeth	25	96
Diametral pitch	5	
Pitch dia, in.	5.000	19.200
Addendum, in.	0.200	0.200
Outside dia, in.	5.400	19.600
Pressure angle, deg.	20	20
Face width, in.	1.0	1.0

LOAD DATA	
Speed	= 4000 rpm on pinion
Continuous load	= 1500 lb per in. of face
Cycles at continuous load	= 200 million
Maximum load	= 3500 lb per in. of face
Cycles at max load	= 20 million

Since the deflection constant of the first pair is 0.00335 in. at 5000 lb-in. torque, and the deflection constant of the second pair is 0.0019 in. at 5000 lb-in., the load is

$$\text{First pair, } \frac{0.0019}{0.00335 + 0.0019} \times 5000 = 1800 \text{ lb-in. (34\% load)}$$

$$\text{Second pair, } \frac{0.00335}{0.00335 + 0.0019} \times 5000 = 3200 \text{ lb-in. (66\% load)}$$

The results just calculated show that this pair of teeth would carry 34 percent load at 5.5 degs roll and 66 percent load at 23.5 degs roll. By making calculations in this manner the percent load can be plotted for all positions of the pinion teeth. In Fig. 6, the curve labeled "percent load, unmodified teeth" shows the result of such calculations.

Suppose that the gear designer wished to modify the profile of the pinion (or the gear) so that the teeth would enter and leave mesh with no load. It would be possible to accomplish this if the involute of the pinion were 0.0019 in. higher at 23.5 degs roll than it was at 5.5 degs roll. Going back to the deflection curve in Fig. 5, it will be noted that a single pair of teeth will carry full load at 23.5 degs. with 0.0019 in. deflection. The modification curve shown in Fig. 6 is calculated to give no load at 5.5 degs roll and 33 degs roll. Based on this curve, the curve "percent load, modified teeth" can be determined.

The above example illustrates a method for determining tooth modi-

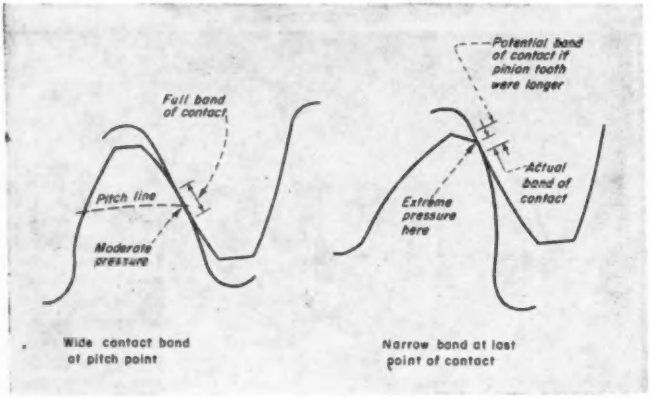
Full bond of contact
Pitch line
Moderate pressure
Wide contact bond at pitch point
Potential bond of contact if pinion tooth were longer
Actual bond of contact
Extreme pressure here
Narrow bond at last point of contact

Fig. 4—Modifying the pressure angle to minimize a cutting action on the pinion at at the first point of contact concentrates the load over a narrow band at the last point of contact. Relief of the tooth tip or root is the logical modification.

fications for heavily loaded teeth. In actual practice, the modification would probably not be as large as that shown in Fig. 6. Although this modification would give a very smooth running pair of gears at full load, it would run rough at light load. Also, the tips of the teeth would get by without doing any work, but the middle of the tooth profiles would have to carry heavier loads.

Sample Problem in Tooth Modification

The principles involved in tooth modification probably can be best illustrated by a sample problem. Let us assume that overall design limitations require a set of spur gears to meet the conditions shown in Table I. This data indicates that the gears are heavily loaded and are being operated at a pitch line velocity of 5236 feet per minute.

The first step is to calculate the diameters at the first and last points of contact, and the tooth contact ratio. Using the method described by the writer in PRODUCT ENGINEERING, March 1948, page 154, the following results are obtained:

Form diameter of pinion, $d_F = 4.739$
Form diameter of gear, $D_F = 18.890$
Contact ratio, $M_P = 1.73$

Since the pinion is driving, contact will start at 4.739 in. dia and end at 5.400 in. dia. These diameters are converted to degrees roll either by reading a graph or by solving the following equation.

Deg roll $= \theta_1 =$

$$\sqrt{D_1^2 - (D\cos\phi)^2} \times \frac{57.295}{D\cos\phi}$$

Where
D_1 = Diameter at which deg roll are desired
D = Pitch diameter
ϕ = Pressure angle

The diameters at the first and last points of contact converted to degrees roll are:

DEGREES ROLL

	First point of contact	Last point of contact
Pinion	7.5 deg	32.5 deg
Gear	24.3 deg	17.8 deg

The next step is to construct a graph for charting the modification. The degrees roll of the gear is plotted against the roll of the pinion as shown in Fig. 7. In making a chart of this type, the first step is to plot the degrees roll for the pinion and gear at the first and last points of contact. Then a straight line is drawn joining the points. It will be noted in Fig. 7 that this line strikes the point 20.85 degs when read on either the vertical or horizontal scale. This point corresponds to the condition of pitch point contact. Below it is a triangular shaded area; all of the modification applying to this region is intended to be applied to the gear addendum. Another shaded region is shown above the pitch point; the modification for this region will be applied to the pinion addendum.

The amount of modification to be used will depend on the deflection curve for the pair of teeth. Preferably this curve should be established by precise test measurements in the laboratory as previously shown, or by careful calculations. It it is not possible to spend the time and effort to make a precise determination of the deflections, the deflection at the worst load point on the pinion may be approximated by the following formula, assuming that the teeth are 20 deg pressure angle, standard addendum, and have a whole depth great enough to permit a full radius fillet, which will improve the beam strength of the tooth.

Total deflection $= P' \times 3.3 \times 10^{-7}$

where P' equals the tangential driving pressure in lbs per in. of face width.

In the example being considered this

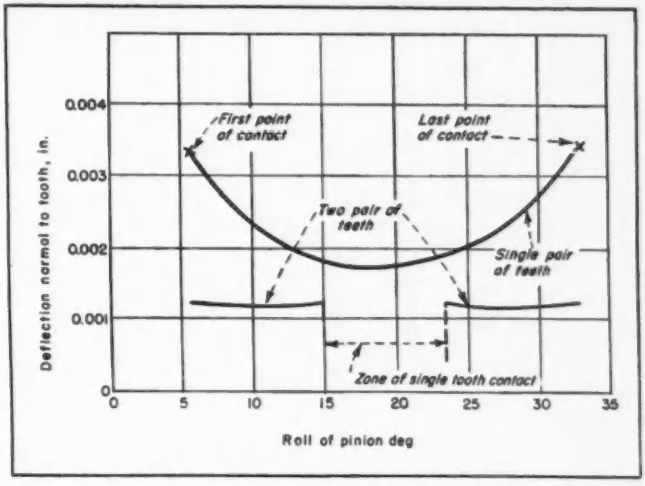

Fig. 5—Tooth deflection at a torque of 5,000 in.-lb. for teeth of 20 deg involute spur gear set having a diametral pitch of 5 and a 20/80 speed ratio.

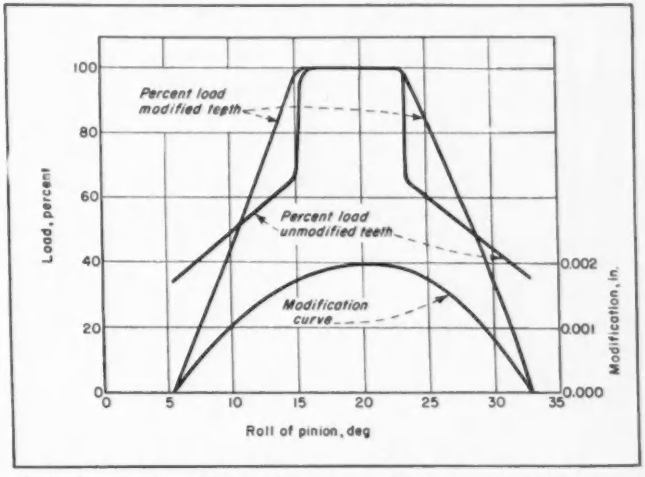

Fig. 6—Percent load carried by modified and unmodified teeth on the pinion (or gear) of the gear set for which the deflection curve, Fig. 5, was obtained.

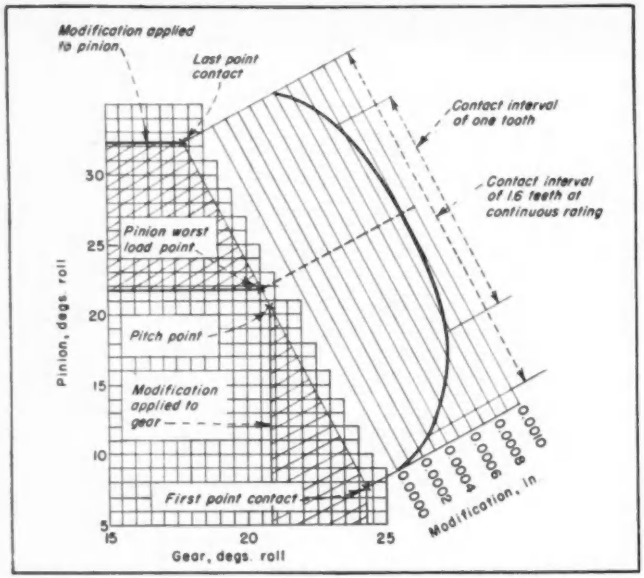

Fig. 7—By plotting the degrees roll of the gear and pinion at the first and last point of contact and connecting those points with a straight line, a graph is obtained for charting the tooth modifications.

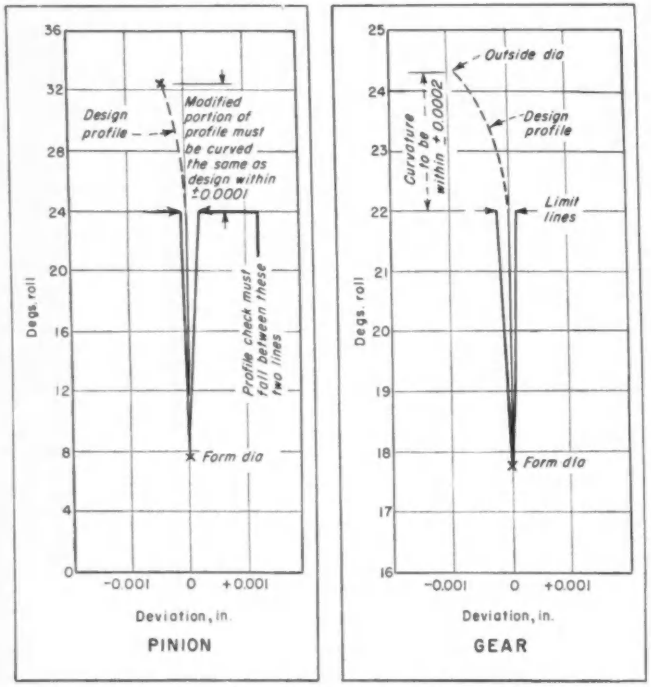

Fig. 8—Specifications for modifying the addendums of the gear and pinion having the dimesion and operating under the conditions shown in Table I. All modifications could have been put either on the gear or on the pinion.

would mean that the deflection would be 0.0011 in. for the max load and 0.0005 in. for the continuous load. If no modification were provided this would mean that under max load the gear tooth would try to remove a chip of 0.0011 in. thickness each time it engaged the pinion flank at the first point of contact. Quite obviously this would be a dangerous situation and premature failure could be expected. This failure might follow the chain of events of first involute form destruction, then rough running and pitch line pitting, and finally tooth breakage. Or it might be that the removal of metal at the pinion flank and the fretting corrosion in this area would set up a region of localized stress concentration which would cause the teeth to fail quickly by direct breakage. The exact mechanism of failure would depend on many factors such as kind of lubricant, temperature, inertia of driving and driven apparatus, surface hardness of teeth, and fatigue strength of teeth. It is beyond the scope of this article to discuss all these factors in detail.

If enough modification is provided to completely relieve the tips of the teeth under max load, the set would run rough under continuous load. Since the set must run 200 million cycles under continuous loading conditions it is very risky to have it running rough. If only enough modification is provided for the continuous load it may not relieve the tips sufficiently for the max load.

In Fig. 7 there is a point plotted and labeled, "pinion worst load point". This point is located at 21.9 degs, just one tooth interval beyond the first point of contact on the pinion. For the example chosen, one tooth interval corresponds to 14.4 degs roll of the pinion. In making up the modification chart, a line was drawn normal to the worst load point. Since max deflection will occur at this point, the modification curve should have its high point also at this point. The difference in the modification curve between the worst load point and the first point of contact will indicate how much clearance is provided to compensate for teeth deflection so that a tooth just entering mesh will enter without shock. For instance, in Fig. 7 there is a modification difference of 0.0009 in. between these two points. With a full load deflection of 0.0011 at the pinion worst load point the modification provided of 0.0009 in. would permit a tooth to enter mesh with an interference of only 0.0002 in. under the max load.

A compromise modification intended to provide protection under max load

but smooth operation under continuous load is shown in Fig. 7. This modification curve is proportioned so that it will accomplish the following if the gear teeth are precisely made to the modification curve.

1. At little or no load, there will be an involute error of only 0.0001 in. in the length of roll corresponding to one tooth interval.

2. At the continuous load rating, the duration of contact will amount to 1.6 teeth. There will be almost no load at the first point of contact and light load at the last point of contact. The angular velocity will be quite uniform.

3. At the max load rating, the duration of contact will amount to the full 1.73 teeth. There will be a very mild load at the first point of contact and a moderate load at the last point of contact.

Specifications for the pinion and gear profiles in the example just considered are given in Fig. 8. The dashed curve shows modifications exactly as called for on Fig. 7. It will be noted that only the addendums of each member are modified. The modification could have all been put on the pinion with the gear left true or it could have been all put on the gear. The method shown of splitting the modification between the gear and pinion but putting it on the addendums only has been favored in some shops.

The limit lines allow the slope of the true part of the pinion to vary between + 0.0002 and — 0.0001 in. On the gear, the limit lines run between + 0.0001 and — 0.0002 in. With this slight amount of unbalance, most of the profile error comes in the most favorable direction. The modified portion of the profile is held to the design curvature within ± 0.0001 in. on the pinion and ± 0.0002 in. on the gear. These profile limits are very close as far as usual gear shop practice goes and yet it can be seen that allowing even this much tolerance will tend to make it doubtful whether all sets of gears will perform as expected. A very high degree of precision in manufacture is required to make profile modifications effective.

A gear that was operated under more severe conditions of load than that given in the preceding example is pictured in Fig. 9. Extensive profile modifications were made to protect the teeth. The photograph of the gear taken after prolonged operation of the set shows that the grinding marks are still clearly visible. Only faint and scattered traces of wear are apparent at the first point of contact, which in this case is the gear tooth tip. Involute checks of pinion and gear showed no measurable wear.

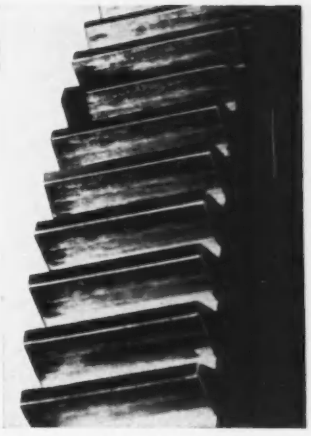

Fig. 9—Condition of gear having modified tooth profiles after prolonged operation under severe loads. Grinding marks are still visible. Width of tooth face is approximately 1.0 inch.

Railway Coach Has Pneumatic Rubber Tires

A "SILENT TRAIN" equipped with pneumatic rubber tires is running on the Paris-Strasbourg route in Europe.

The idea of the rail tire goes back to 1929, when experiments carried out by the Michelin Company led to the "Micheline" rail coach. But the problem of designing a bogie that would, in the event of a blowout, permit continued operation at full speed, became so formidable that development was discontinued. Work was resumed in 1939 and continued during the occupation.

The rail tire, by its own resiliency, partly takes up differences in track level, the axles being fixed and equipped with roller bearings. Each of five axles is linked to the bogie chassis by an elastic device known as a "Bibax." This device consists of a rubber block of which the elasticity is precisely controlled. The bogie thus possesses the necessary flexibility needed to "hold" the track.

Suspension for the bogie consists of two transverse springs sliding on runners arranged on cross-members and two longitudinal springs to which the body is connected by links. The bogie chassis, axles and wheels form a rigid unit that spreads the load over the other nine wheels when one wheel is deflated. The damaged tire is therefore not loaded and the train can continue to a service depot.

Each coach is mounted on two bogies having a total of twenty wheels. Since the pneumatic tire calls for lightweight construction, technicians had a new problem to solve, that of lightness, though the conception of safety was not to be lost sight of on that account. Thus the stainless steel train produced by Ets. Carel Fouche has been considerably lightened (16 tons per coach), when compared with the latest production models travelling the French State Railways. The "silent" coaches are therefore not as massive as the standard assemblies, but because of their stainless steel construction, they offer a satisfactory guarantee of safety.

In the event of a collision, protection for passengers is afforded by a combination of devices. The object of these is to absorb a large number of foot pounds of energy by allowing considerable displacement to take place throughout the train.

At the ends of the coaches are special pneumatic shock absorbers, fitted to the walls. These absorbers are of sufficient diameter to make contact with adjacent cars even in cases where coaches are greatly distorted. If distortion is too extensive for contact to be assured, the compressibility in the outboard face of the shock absorber prevents piercing of the walls on adjoining coaches. Bursting of these pneumatic "collision" devices dissipates some 14,600 ft-lb of energy before permanent deformation of the framework occurs.

The braking system is of the oleo-pneumatic type. Each bogie is served by a special oil system that terminates in a Lockheed master cylinder. In turn, the latter is coupled to a compressed-air receiver containing a diaphragm. The bogie wheels are all braked by drums of large dimensions following the designs adopted on automobiles.

The rubber-tired train derives many of its qualities from rubber. Not only is it used in the wheel fittings, but also in the suspension and the anti-shock devices, not to mention the part it plays in the interior furnishings of the coaches.

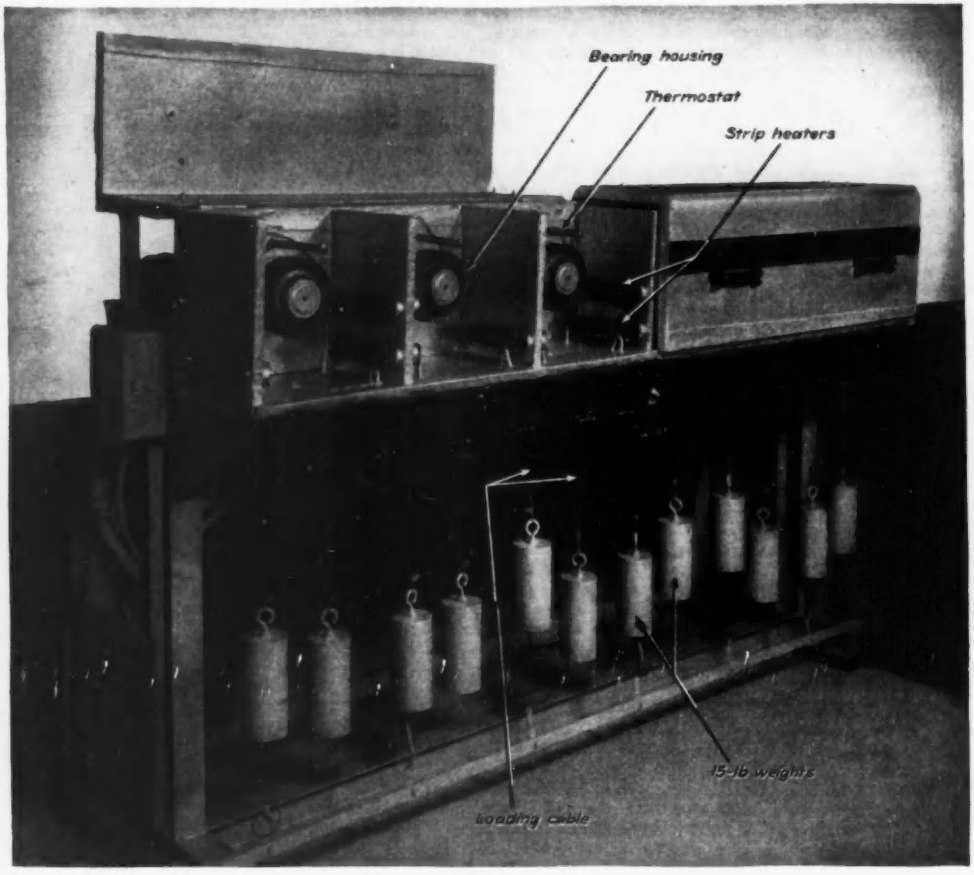

Fig. 1—Two 15-lb weighs suspended on cable wrapped around each housing load the bearing containing a test grease. Strip heaters and thermostats control ambient temperature of the insulated cubicles. Machines consist of four groups of twelve bearings.

Electro-Mechanical Tester Evaluates Ball Bearing Greases

I. AXELRAD and M. M. FROMM
Materials Engineers,
Westinghouse Electric Corp.

ELECTRO-MECHANICAL grease testing machines that simulate field conditions and evaluate greases for ball bearings provide accurate quantitative data through the use of a technique not previously utilized in this type of equipment. The machines consist of four groups of twelve bearings, each individually motor-driven, and special electronic controls that periodically record bearing temperatures throughout tests of any duration.

Test greases are placed in bearings enclosed in a thermostatically controlled oven for which the ambient temperature can be adjusted to duplicate the operating range for the grease under test. Conventional petroleum oil-soap greases are tested at an ambient that produces a bearing temperature of 110 C, while high-temperature greases, such as the silicones, are tested at an ambient producing a bearing temperature of 125 Centigrade.

A radial load is impressed on each bearing by a cable that makes one complete turn around the bearing housing as shown in Fig. 1. Fifteen-pound weights are hung on the ends of this cable. The bearing housing is a cast iron cylinder, slip-fitted and locked to the outer race of the bearing. The loading cable prevents the housing and outer race from turning, since one end of the cable is held in place by a cali-

brated helical spring. Movement of this spring is utilized to activate a shut-off switch for the driveshaft to which the inner race is locked. Any change in the consistency of the grease produces a sudden torque that automatically shuts off power to the drive motor.

Outside the oven, the driveshaft is mounted in two ball-bearing pillow blocks. Nominal speed adjustments are set by combining different sized pulleys, while final adjustments are made on a variable-pitch pulley on the end of each driveshaft. One-sixth horsepower motors hung beneath the framework on rocker mounts equipped with springs maintain proper V-belt tension.

Before testing a grease, each new bearing is carefully washed, loaded with a weighed quantity of the test grease and mounted on the shaft. The housing is then fastened in place and the loading cable, with weights removed, wrapped around the housing.

During the break-in period, bearings run continuously at room temperature for 24 hours. Bearings that exceed a 10-degree Centigrade rise above ambient are rejected—their fit-up or internal clearance is too close for test purposes. Such bearings will "work" the grease more severely and cause a relatively early failure.

After being broken in, the bearings are loaded—weights attached to the cable—and the oven heated. A daily schedule is maintained—16 hr on and 8 hr off, the latter period usually spanning the daytime working hours. This schedule is used as experience has shown that cold starts accelerate failure more rapidly than continuous running.

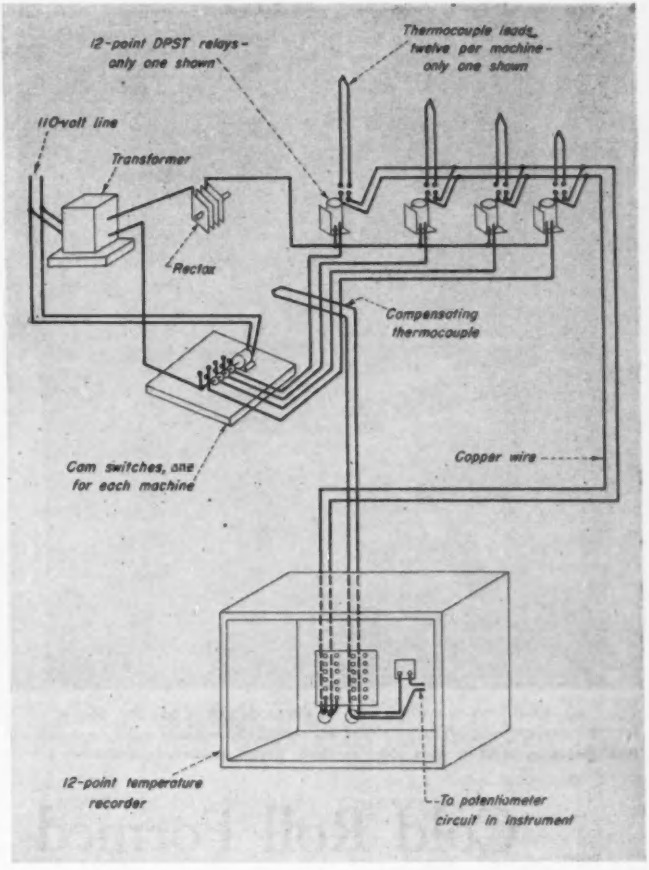

Fig. 2—Twelve-point temperature recorder handles four grease testing machines. Thermocouples from each machine are switched into circuit for 15 min of every hour.

Control Equipment

Instrumentation for each group of bearings consists of an oven temperature controller, a bearing temperature recorder and a schedule-time control. The time controller is of the single cam type with adjustable trip-fingers. The timer switch controls four contactors that energize the oven heaters and motor circuits. The liquid-filled oven temperature controller has a range of 110 to 150 C and maintains temperatures within ±2 Centigrade.

To measure bearing temperatures, an iron-constantan thermocouple is inserted through a hole in each housing to the outer race of the bearing. Temperatures are recorded on a 12-point electronic strip-chart potentiometer having a printing cycle of 30 sec and a range −100 to +200 Centigrade. Forty-eight temperatures are recorded at twelve points as shown in Fig. 2. Four sets of twelve thermocouple wires are brought to four 12- circuit, double-pole, single-throw, normally-open relays. Coils, energized by 48 v d-c, are actuated by a 4-cam timer that closes each circuit for 15 min of each hour. Contacts of corresponding thermocouples on each relay are parallel-connected into the recorder. The relays, as well as the power transformer and rectox assemblies, are housed in a sealed cabinet usually located on top of the temperature recorder housing for convenience of wiring.

Copper wire is used to connect the relays to the temperature recorder, the cold junction being located within the cabinet. Temperatures inside the enclosure are considerably higher than room ambient because of the heat dissipated from the rectox, transformer and relay coils. Compensation for cold-junction error is effected by a single thermocouple installed in the control box and connected into the potentiometer balancing circuit.

With this instrumentation, each bearing temperature is recorded about three times every hour. More frequent readings are unnecessary since the temperatures do not vary rapidly and the testing periods continue for as long as 4,000 hr before failures occur.

The time of failure is determined by inspection of the recorder charts. Since temperatures for each group of bearings are recorded for 15 min during each hour, the time of failure can be spotted within 45 min by the sudden rise in temperature and by the subsequent temperature drop.

In this manner, is is possible to determine the time of grease failure during a 1,000-hour test to an accuracy of 0.075 percent, a figure well beyond the reproducibility of a given grease.

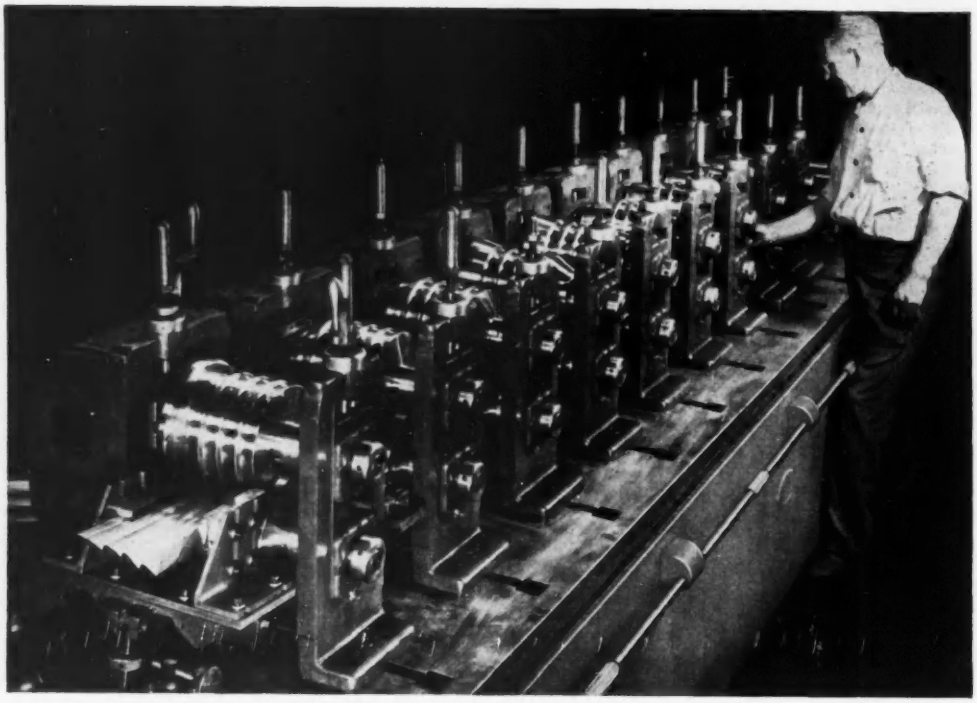

Fig. 1—Cold roll forming machine used for the production of trim for sides of railroad passenger cars. Production rates of 100 fpm and over, and adaptability to almost any section and material make the cold-forming process suitable for decorative and structural shapes up to 80 in. wide and ¼ in. thick. Plated, painted, or cold-rolled stock can be formed on the same machine.

Cold Roll Formed Sections

E. J. VANDERPLOEG
The Yoder Company

COLD ROLL FORMING consists of cold-shaping flat metal strip into a desired shape by passing it between progressive sets of forming rolls. Each pair of rolls, set on a horizontal axis, forms additional contour in the part, until in the last roll pass, it reaches its final shape. Because of its high production potential and adabtability to the forming of either simple or complex shapes, the process is used for the manufacture of decorative trim, tubing, ducts, panels, structural members, coiled sections, and other components for such widely diverse products as automobiles, aircraft, railway cars, furniture, bicycles, toys, prefabricated buildings, appliances, and framing or underpinning for industrial machinery.

In addition to these production advantages, however, there are many benefits of the process from the design viewpoint: (1) structural sections, if properly designed, have a high strength-to-weight ratio; (2) parts can be fluted, seamed, notched, beveled, welded, punched, coiled, curved and embossed simultaneously with the forming operation; (3) any of the common metals—cold rolled steel, alloy steels, aluminum, brass, bronze, zinc, copper—as well as painted or plated stock or bimetal sections can be formed; (4) the finish of the stock is not marred; and (5) tolerances ranging from 0.001 to 0.005 in. can be held, depending on the accuracy of the stock as it comes from the mill and on the size and shape of the section.

Standard Equipment

Standard roll-forming machines are classified by type according to the number of bearings supporting each spindle. Those on which only one end of the roll spindle is supported, the other end extending out over the base of the machine, are known as outboard types; those on which bearings are mounted at both ends of the spindle, as shown in Fig. 1, are known as inboard types. Generally, the inboard machine is the most versatile, since the spindles are supported at both ends, and consequently it can be used for both light or heavy sections. The outboard machines are used mostly for lighter work; they are slightly lower in first cost and easier to set-up.

The number of rolls that are mounted on the machine varies with the nature of the section to be formed, and with the type and thickness of the stock. Simple shapes, such as angles, channels, or tubes, require fewer roll passes than more complex sections. Cold-rolled steel, being more ductile, can be formed in fewer passes than stainless steel, which is more brittle and subject to cracking. The number of roll passes ranges from 4 to 20,

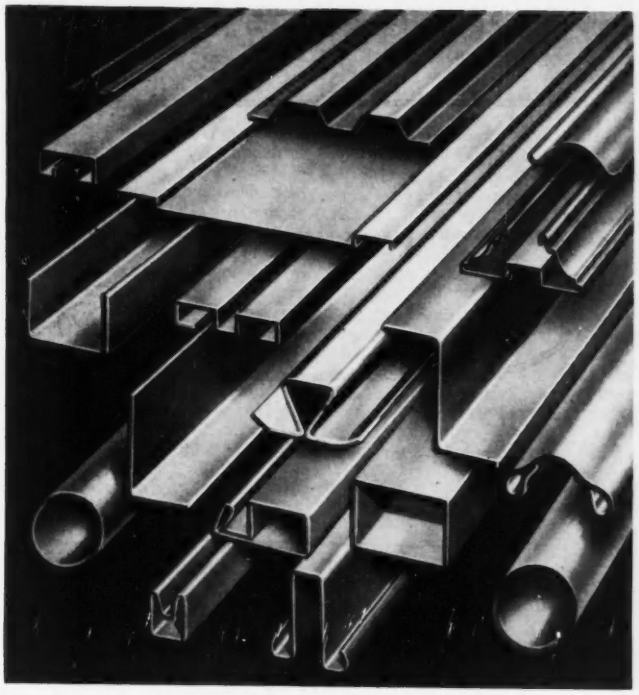

Fig. 2—Typical sections formed by cold-rolling. For cold rolled steel up to ¼ in. in thickness, there are few limitations on section contour. The formability of all materials depends on ductility, hardness and thickness of the section.

this latter number being about the maximum ever used on a standard machine.

The thickness of the stock that can be formed varies from about 0.10 in. to ¾ in., and the width, from a fraction of an inch up to 40 in. or more. Special machines have been built with spindle diameters as large as 15 in. for forming tubing up to 36 in. dia, so practically, there is no limitation to the size of the stock or the section. However, with an increase in size, the cost of the equipment becomes greater, and the demand usually smaller. Most sections are made from coiled strip less than 0.125 in. thick and 20 in. wide. In Fig. 2 a representative group of sections is shown.

Formability of Materials

With a given size of machine and dimension of stock, the severity of the contour that can be formed, and the speed at which the machine can be operated depend on the type of material used. Cold-rolled mild steel SAE 1010 to 1020 is usually the standard with which all other materials are compared, not only because it is ductile and easy to shape, but also because it is probably most widely used. Ninety-deg angles with negligible radii can be formed with this stock if the section is first grooved or crimped in one of the initial roll passes; but inside bend radii equal to the thickness of the stock are considered standard practice and are preferred for most purposes.

Forming speeds range from 50 to 200 fpm, depending partly on the kind, quality and size of stock, and partly on the profile to be formed. Higher speeds would be practical in many cases were it not for limitations imposed by materials handling and the cutting-off operation.

The formability of high carbon steels and alloy steels is governed by their ductility and hardness. Stainless steels for roll forming may be divided into three main groups: The straight chromium types, such as AISI Type 410 containing between 11.5 and 13.5 percent chromium and 0.15 percent carbon max; the chromium-nickel types similar to AISI 302, which contain from 17 to 19 percent chromium, 8 to 10 percent nickel, and 0.20 percent carbon max; and srtaight chromium steels containing between 14 and 18 percent chromium, and 0.12 percent carbon maximum.

The formability of AISI Type 410 stainless steel is considered by many manufacturers to be similar to the SAE steels containing about 0.30 percent carbon—SAE 2330, 3130, 4130, and 6130. At room temperature, its percent elongation in 2.0 in. is about 30, and it can stand a 76 percent reduction in area. AISI Type 302 is the standard 18-8 grade, is considered well suited for cold forming operations, and is often the type specified for decorative moldings, except when corrosive conditions are especially severe. Its elongation in 2 in. is 63 percent, it will withstand a 73 percent reduction in area, and combines both ductility and toughness.

AISI Type 430 is ferritic instead of martensitic or austenitic in structure. Most decorative trim on automobiles —body moldings, radiator grills, headlight rims—are made of this particular grade. However, when corrosion resistance is especially important, Type 302 generally is specified. In addition to these general types, some manufacturers make special grades of stainless that they recommend for roll forming operations.

All grades approach the ductility of cold-rolled carbon steel, and can be cold formed, but at reduced speeds and with a larger number of rolls to allow for greater spring-back. If cracking occurs, bend radii must be increased.

Forming speeds generally range from 25 to 75 ft per minute for stainless. The heat that is generated when stainless steel is formed at higher speeds tends to cause scoring of the surface of the material. The inside radii should not be less than 1-½ times the sheet thickness; double the thickness is still better and should be used whenever possible. Except for simple sections or sections with easy curves, stainless should be limited to thicknesses not over 0.080 inch. The rolls must be lubricated to prevent tiny fragments of the stock from accumulating on the rolls, since such accumulations would otherwise cause scoring, as just referred to. In all cases, a high finish is required initially—and must be maintained—on the rolls.

Nickel or a nickel alloy, such as Monel or Inconel, is slightly more difficult to form than stainless steel, and consequently speeds are slower; thickness limitations are about the same as for stainless steel. Magnesium can be roll formed but it must be heated; this is usually accomplished by batteries of infra-red lamps mounted

on the entry table and on top of the roll stands. In the cold state, it work-hardens rapidly, and therefore tends to crack.

Zinc and zinc alloys are among the easiest materials to form; they are used primarily for weather stripping. Aluminum is used for such items as venetian blinds, aircraft framing members, frame sections for storm sash and screens, and for other decorative and utilitarian parts including structural members for small buildings. The unhardened grades are recommended because they have less tendency to crack. However, according to published data, the non-heat treatable alloys 2S, 3S, and 52S with the following tempers have been cold roll formed: 0, ¼ H, ½ H, ¾ H, and H. Not all alloys or tempers can be used for every shape, as the section thickness and profile governs the choice; this also is true of the heat-treatable alloys 17 S-O,

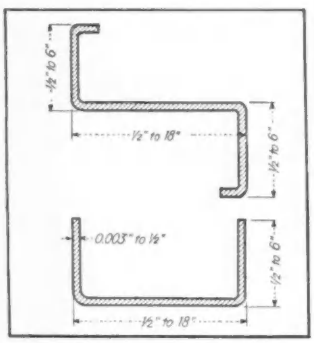

Fig. 3—Size ranges of standard channels and Z's that have been successfully produced. Aluminum aircraft framing-members also usually are cold roll formed.

17 S-T, 24 S-O, 24 S-T, and of the various clad alloys. For aircraft parts, 24 S-T grades have been formed into channel sections such as shown in Fig. 3, in thicknesses up to $\frac{5}{16}$ in. Speeds up to 100 fpm are possible. The softer grades of aluminum are difficult to roll-form in thickness less than 0.015 in. because the material may not hold its shape. Harder grades sometimes can be run thinner, and clad sections as thin as 0.005 to 0.006 in. have been successfully formed.

Thin sheets often are formed around a less expensive material, such as cold-rolled carbon steel, to obtain a part that has good appearance and high corrosion resistance, and yet is less costly than a solid section made of the higher priced material. The combining of two or three materials in the cold roll

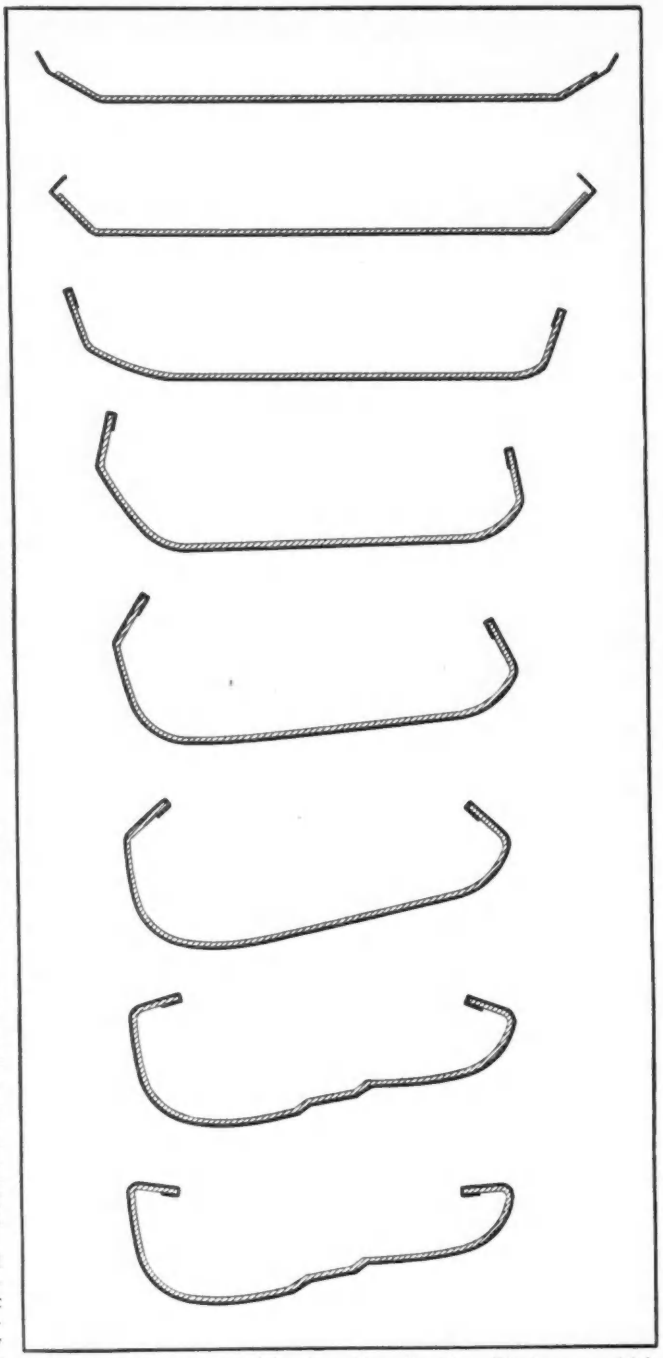

Fig. 4—Successive steps in roll forming a bi-metal section. The inner material is cold rolled steel. The cladding is stainless steel. Production is at the rate of 100 fpm. Principal advantage of such construction is the savings made in material cost.

forming process is readily accomplished and adds litle to the cost.

Stainless steel and copper sheets also have been used as a covering for low carbon steel sections. In all of these cases, the covering stock is fed into the forming machine with the base material. The covering is formed around the base stock, and usually is locked into place, as shown in Fig. 4. Such bimetal sections, in addition to being less costly than solid metals made entirely from more costly materials also are often cheaper than plated stock.

When plated stock is preferred, in some instances it may be pre-plated and then formed. For intricate sections that would be difficult to plate uniformly after rolling, this method of production is especially suitable. Chromium plate, being hard, is therefore difficult to shape without cracking, as is nickel. Zinc and cadmium are easier, although a lubricant is necessary to avoid marking.

Painted stock also can be formed. The base metal is usually, although not necessarily, low carbon steel. There are many precautions that must be observed, however, and the forming machine manufacturers naturally will not guarantee results since the quality of the stock and the coating is beyond their control. The paint can be either a flat coat or an enamel. It must be flexible enough to stretch or contract around the formed sections, yet hard enough to withstand the roll pressure. The rolls must be kept clean, to prevent dirt from being pressed into the coating. Roll pressures must be light, and the rolls must not "wipe" the section. Wiping is most likely to occur on the sides of deep sections.

Prepainted stock is used by the Lorentzen Hardware Mfg. Co. for the venetian blind sections shown in Fig. 5. All parts of metal blinds now are formed from roller-coated stock—the bottom rail *A*, the head channel *B*, the metal facer board (or cornice) *C*, and the slats, *D*. These parts are made of cold-rolled steel ranging in thickness from 0.015 to 0.025 in. They are first electro-galvanized and Bonderized, after which a synthetic enamel is applied to the strip with rubber rolls and then baked. Roll forming of these sections is performed at speeds of 100 fpm or more—the same as for uncoated material. The sections then are cut to required length in a flying shear of special design, again without damaging the paint. When painted head channels are formed at speeds of 100 fpm, sections as short as 6 in. in length can be cut without deformation or flattening at the ends. However, ordinarily, 12 in. is the minimum length that can be cut at speeds of this magnitude.

Briefly, the advantages and limitations of roll forming pre-painted stock can be summed up as follows:

1. Cold roll forming of painted stock is practical provided a hard paint with good ductility is used.

2. One limiting factor is the bend radii on the section. Although radii of $\frac{1}{32}$ in. have been formed on 0.020 in. stock without damaging the finish, radii of $\frac{1}{16}$ in. are recommended for stock ranging from 0.015 to 0.025 in. thick. On heavier sections, the radii should be about 3 times the stock thickness.

3. No additional rolls ordinarily are required for coated stock, but the rolls may require more careful adjustment after making a roll change so that forming pressures may be kept at a minimum over the entire width of section.

4. Speed of forming may, under favorable conditions, be as high as for uncoated sections.

5. Although experience to date with prepainted stock has been confined to cold rolled steel and to aluminum, roll forming of painted sections made of other materials should present no serious problem.

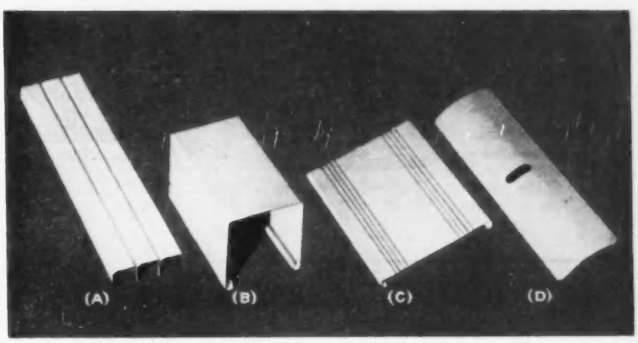

Fig. 5—Sections for venetian blinds cold roll formed from prepainted and baked enamel stock by the Lorentzen Hardware Mfg. Company. Only precautions: Use of a ductile paint, bend radii, three times stock thickness, and accurate adjustment of rolls to prevent excessive pressure speed of rolling is the same as for unplated stock.

Design Analysis

Besides the material to be used, and the dimensions of the stock, other factors governing whether a part is suitable for production by the cold roll forming process include the production rate that is anticipated, the profile of the shape to be formed; and the auxiliary operations that must be performed on the section.

Production rates of 100 fpm are about average on roll forming machines. Production from 30,000 to 40,000 ft of formed sections per 8-hr day are not unusual. Obviously, therefore, the process is not suitable for parts to be made in small quantities; such items may be more economically formed on a press brake, or in some cases, by extrusion. Different sets of rolls for different contours can, of course, be used on the same machine. If one shape requires fewer roll passes than another, the remaining spindles are not tooled; a sixteen-spindle machine can readily be used for a five or even a two-pass job.

Insofar as profile is concerned, manufacturers of roll forming machines can advise as to what shapes can and cannot be formed from any given metal. Some of the variables have already been mentioned, namely section depth, width, and stock type and thickness. Channels, angles and Z's, as shown in Fig. 3, are relatively easy to form. Tubing, either welded or unwelded, square, rectangular, star-shaped, oval, round, or irregular in shape, and ranging from $\frac{1}{8}$ in. in diameter up to 26 in. dia have been produced. Structural parts and decorative trim are formed in innumerable shapes, a few of which are shown in Fig. 2. Actually, the determination of whether a shape can be cold roll formed, and the number of rolls required to produce it, usually is left to the manufacturer of the machines, who will design and produce the rolls, and assume responsibility for satisfactory performance.

The engineer who has a working knowledge of the formability of materials of different compositions and thicknesses can, of course, sketch out roughly the shape that a section should

take in successive roll passes to see whether a prohibitive number of rolls might be required. For cold rolled steel up to $\frac{1}{8}$ in. in thickness, there are few limitations on section profile.

In addition to its ability to roll a strip or sheet into a required shape, the roll forming process has an additional advantage: Machines often can be tooled to perform auxiliary operations. These operations can be classified as follows:

NOTCHING—Frequently, the stock is notched as it enters the roll forming machine, either to prevent excessive deformation (if the section is heavy or complex) during assembly. Standard flying shear machines made especially for use with roll forming machines perform this operation.

PIERCING—If the section thickness is not great, piercing punches can be mounted on the rolls to pierce holes in the strip as it is being formed. While the holes are deformed more than if drilled, they are satisfactory for screws or nails.

EMBOSSING—Embossed rolls can be used to produce shallow designs or lettering on the stock simultaneously with the forming operation. This engraving operation usually is done in the first or second roll pass, unless only a narrow section is involved, in which case it can be performed in any convenient set of rolls. If the engraving is deep, it is done in one of the last roll passes so that it will not be flattened by subsequent roll pressure.

CUTTING-OFF—Flying shear cut-off machines, or circular saw type machines may be synchronized with the forming machine to cut off sections to the required length as the shape leaves the forming machine; the minimum length of section that may be cut depends on the speed at which the forming machine is operating. The major difference between the types is that the flying shear machines may flatten tubular or hollow sections to a slight extent, while circular saw machines will form a burr. The latter type is almost always applied on sections over $\frac{1}{8}$ in. thick.

CURVING AND COILING—Some parts, like bicycle rims, structural members for Quonset buildings, aircraft framing members, and the like, may be curved or coiled. A special die or mechanism can be incorporated after the last roll pass for this purpose. If the section is extremely heavy, an auxiliary set of rolls may be required, but it is an unusual section that cannot be curved or coiled on the same machine as used for forming.

LOCKED SEAMS—In making unwelded tubular members, it may be necessary to lock the seams together. Typical lock-seam joints are shown in Fig. 6. This method of joining is widely used when the material cannot be welded, or the stock is too thin for welding, or when the investment in a complete tube mill is not warranted.

WELDING—Butt-welding of pipes and tubes is perhaps the best known application for roll forming machines. Although electric resistance welding with either 60 or 180 cycle current is most common, electric arc or gas welding also is used for materials unsuited for resistance welding, notably stainless steel. The end uses of such tubing are too numerous to mention.

Speeds vary from 2·5 feet per minute for welding stainless steel, to 35 to 150 fpm for mild steel. Fig. 7 shows average speeds on various welders for joining plain carbon steel. These curves disregard variations in stock composition and operator skill, so that higher speeds often are obtained.

SLITTING—Stock can be trimmed to the correct width for forming in the entrance rolls, if necessary, or in the auxiliary slitting machines. Occasionally, several parts can be formed from a solid strip of material, and a slitting roll used to sever the pieces. This is possible even if the shapes are dissimilar in cross-section, providing they are not too wide to be accommodated in the machine.

Closely allied with the production of multiple sections is the technique of forming one section from several different materials. Wire, rod, cord, wood and other materials can be inserted inside a metal cover.

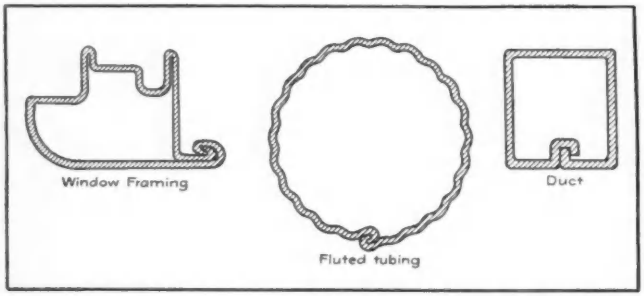

Fig. 6—Locked-seam sections made on cold roll forming machines. The framing for windows and screens is made of aluminum strip in a 12-pass machine. The tubing and duct are only two of an unlimited number of such products.

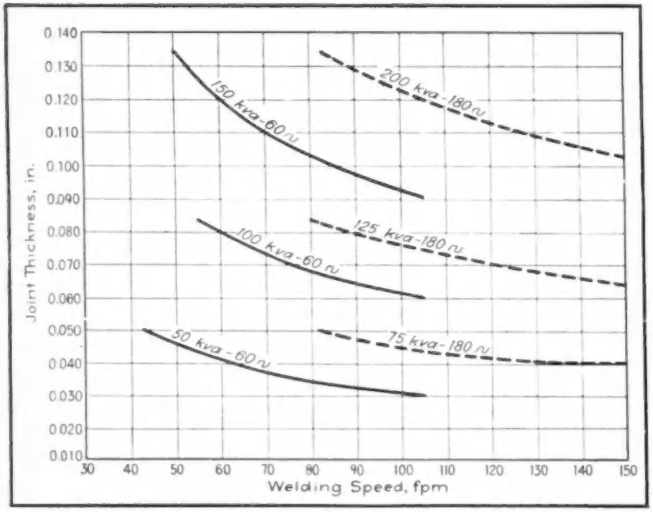

Fig. 7—Average welding speeds for mild steel in resistance tube-welding machines.

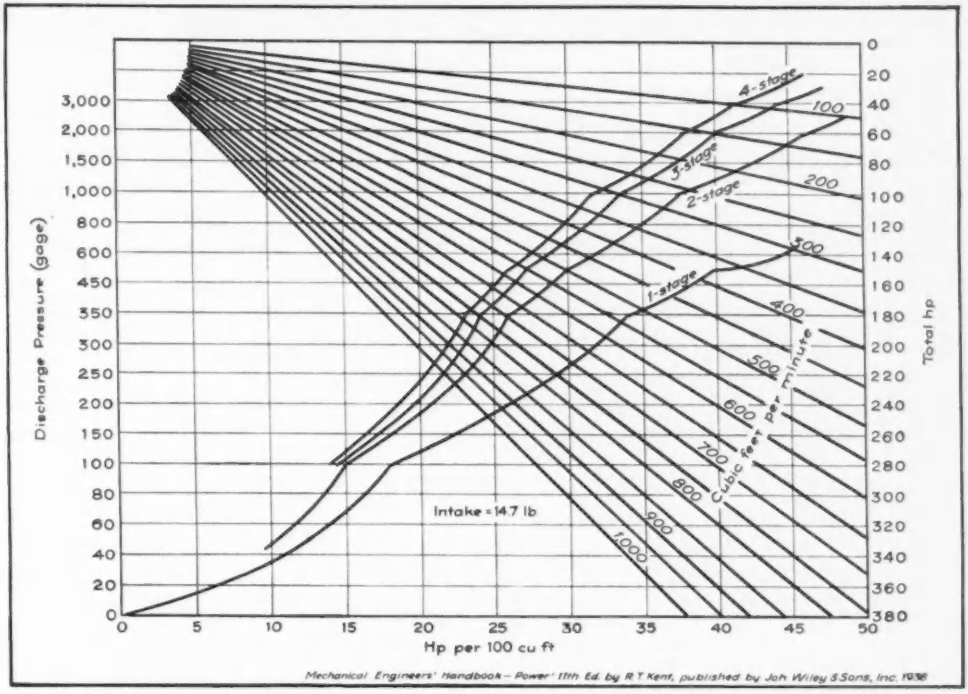

Fig. 1—Required horsepower to adiabatically compress air by single and multi-stage compression—perfect intercooling. To find horsepower run vertically from intersection of the pressure and stage lines to the capacity line, then horizontally to horsepower.

Choice of Operating Pressures for Pneumatic Systems–II

Effect of high pneumatic pressures on compressor and valve selection, moisture content, flow rate control, and general operating hazards. Review of factors governing choice of pressure.

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THE BASIC ADVANTAGES and limitations of high pressure pneumatic systems were discussed in the first part of this article, which appeared in the August issue of PRODUCT ENGINEERING. As pointed out in that article, the power required for the compressor drive is less with high pressure air than with low pressure air for the same number of ft-lb of potential energy delivered to the reservoir (1) because of nearly equal friction in the compressor, and (2) because a more efficient compression curve is obtained.

The work done by air as it expands is the integral under the curve of PdV. The number of cubic feet of "free air" or weight of flow to perform a given amount of work is the same regardless of the relationship between the operating pressure and volume of the cylinder. As may be seen on the horsepower chart, Fig. 1, the power requirement to 3-stage compress 100 cu ft of "free air" to 3,000 psi is 45 hp and to 300 psi it is 23 hp. Thus, with 1,955 more hp, 10 times as much pressure is acquired, indicating favorably a trend toward higher operating pressure for economy of operation as well as a reduction of reservoir and actuating unit size.

The principal reason for this reduction in hp requirements is that the compressor friction loads at high or low pressure are nearly the same, and at high pressures the compressors can be multi-staged with intercooling between stages. To be able to compute the difference in a single-stage and multi-stage compressor, it is of course necessary to first define the type of compression.

ADIABATIC COMPRESSION is the least desirable, although closely approaching actual conditions in practices. In adiabatic compression there is no escape of the heat generated in compressing the air. Thus, a greater amount of work is required to fulfill the same "volume-pressure" and

temperature requirements:

$$W = \frac{k}{k-1}(P_1V_1 - P_2V_2)$$

$$= \frac{k}{k-1} MR(T_1 - T_2)$$

$$= \frac{k}{k-1} P_1V_1\left[1 - \left(\frac{P_2}{P_1}\right)^{(k-1)/k}\right] \quad (1)$$

where K equals 1.406 and PV equals MRT.

ISOTHERMAL COMPRESSION involves the complete removal of all the heat generated by compression of the air, and is theoretically the ideal condition. However, in most practical applications, the time factor prohibits a rate of compression that is slow enough to allow atmospheric cooling, and the power required to cool the air mechanically could not be justified. Neglecting friction, the work per cycle required to compress the air for this condition is

$$W = MRT_1 \log_e \frac{P_1}{P_2} = P_1V_1 \log_e \frac{P_1}{P_2}$$

$$= PV \log_e \frac{V_2}{V_1} \quad (2)$$

where $PV = P_1V_1 = P_2V_2 = MRT$

POLYTROPIC COMPRESSION is the so-called "happy average", for it is the most practical of the three conditions. By water or air cooling, the exponent k can be reduced to the exponent n, thus reducing the amount of work as compared to adiabatic compression. The work required for this condition is

$$W = \frac{n}{n-1}(P_1V_1 - P_2V_2)$$

$$= \frac{n}{n-1} MR(T_1 - T_2)$$

$$= \frac{n}{n-1} MRT_1\left[1 - \left(\frac{P_2}{P_1}\right)^{n-1/n}\right]$$

$$= \frac{n}{n-1} P_1V_1\left[1 - \frac{P_2}{P_1}^{n-1/n}\right] \quad (3)$$

In the majority of cases, n is equal to 1.3. A comparison of isothermal, polytropic and adiabatic compression is shown in Fig. 2.

The foregoing states the conditions for an ideal, theoretical compressor, neglecting friction and clearance. In an actual compressor, clearance is required between the top of the piston and the cylinder head. This of course increases the volume of the cylinder. The added work of compressing a greater volume than is delivered is returned on the intake stroke; however, a slight loss is incurred due to added friction, and the intake volume of air is decreased. Air is drawn into the cylinder at suction pressure P_1, and the ratio of fresh air volume to piston displacement, known as the "clearance factor", may be found as follows:

$$\frac{V_1 - V_a}{V_D} = \frac{1}{V_D}\left[V_D + CV_D - CV_D\left(\frac{P_2}{P_1}\right)^{1/n}\right]$$

$$= \left[1 + C - C\left(\frac{P_2}{P_1}\right)^{1/n}\right] \quad (4)$$

where, as shown in Fig. 3, V_D is the piston displacement, V_a is the clearance volume, V_1 is the total volume, C is the clearance, and V_a is the volume at atmospheric pressure ($P_aV_1 = P_aV_a$).

For air to flow from the atmosphere, known as free air, into the cylinder, it is necessary that there be a differential pressure. Therefore, the pressure P_1 must be less than P_a; the differential is $P_a - P_1$ and the ratio P_1/P_a. Most compressors are rated by "free air capacity" or cu ft per min of atmospheric air; if the volume to be handled per stroke is divided by the volumetric efficiency, the required displacement for the compressor is obtained. This volumetric efficiency may be found by

$$e_v = \frac{P_1}{P_a}\frac{V_1 - V_a}{V_D} = \frac{P_1}{P_a}\left[1 + C - C\left(\frac{P_2}{P_1}\right)^{1/n}\right] \quad (5)$$

Whenever the required pressure must exceed five times the "free air" pressure, it is practical to multi-stage the compressor. The ideal condition is to design the compressor so that each stage does an equal amount of work and the temperature of the air leaving each stage is the same. Also, the air must be cooled between stages to as near the initial inlet temperature as is practical.

The amount of work required in multi-stage compression is shown in Fig. 1, and can be calculated as follows:

$$W_1 = \frac{n}{n-1} P_1V_1\left[1 - \left(\frac{P_x}{P_1}\right)^{(n-1)/n}\right] \quad (6)$$

$$W_2 = \frac{n}{n-1} P_1V_1\left[1 - \frac{P_2}{P_x}^{(n-1)/n}\right] \quad (7)$$

$$W_{Total} = \frac{n}{n-1} P_1V_1\left[2 - \left(\frac{P_x}{P_1}\right)^{(n-1)/n} - \left(\frac{P_2}{P_x}\right)^{n-1/n}\right] \quad (8)$$

where P_1 is the initial pressure in stage No. 1, P_x is the intermediate pressure or discharge pressure from stage No. 1, and P_2 is the discharge pressure from stage No. 2.

There are many applications in which a small, light, compact compressor that will deliver high pressure air is required—and multi-staging often provides the solution. An example of this is the aircraft engine-driven compressor developed by the Westinghouse Airbrake Co. for the Convair 91,000 lb jet-engine bomber, Model *XB*-46. ("Why Pneumatics" SAE Journal, January 1948)

This compressor operates with a 34 psi (gage) inlet pressure from the jet engines' 11th stage of compression and delivers 5 cu ft of free air per min at a pressure of 1500 psi (gage). Due to a minimum of space it was

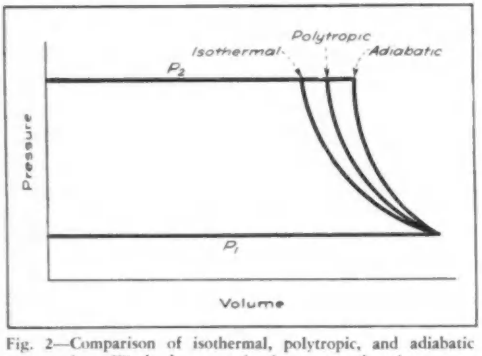

Fig. 2—Comparison of isothermal, polytropic, and adiabatic compression. Work done equals the area under the curves. Polytropic compression is the most practical.

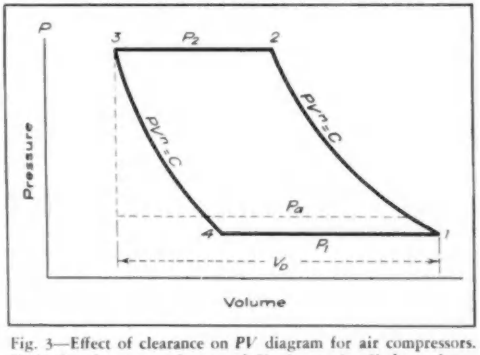

Fig. 3—Effect of clearance on PV diagram for air compressors. V_1 is the clearance volume and V_1 the total cylinder volume. P_a, the atmosphere pressure, must always be greater than P_1.

fied, especially where the compressor ran only approximately 12 min per flight and the added work was of little consequence. This unit, weighing 15 lb, has proven thoroughly satisfactory.

Useful data on the choice and function of compressors will be found in the "Compressed Air Handbook", published by the Compressed Air and Gas Institute, and in the Pneumatic Automotive Equipment Association Handbook "How to Select an Air Compressor"; also in "Air Compressors" by Eugene W. Feller (McGraw-Hill).

Hazards from Moisture

A fourth and important advantage of high pressure pneumatic systems is that there is less possible danger of erosion of equipment components and freezing of system parts than in low pressure systems because there is less moisture in the air.

As may be seen from Fig. 4, the water content or relative humidity of air is dependent on temperature and on pressure. Although the air is denser at high pressures, it has less capacity for storing moisture. And since as much moisture as possible must be removed from pneumatic systems to prevent erosion and corrosion and to minimize the possibility of freezing, the less moisture there is in the air after reaching the reservoir the easier becomes the problem of removing it.

When air is not used at a high rate and there is sufficient time for it to cool in the reservoir—providing the reservoir temperatures are low—the water will condense and deposit, and can be drained off manually or automatically. However, when the air is used at a rate approximating that of the compressor supply, it is necessary to cool it artificially in inter-coolers.

Another, or supplemental method of removing moisture is to use dessicators or dehydrators such as silica gel or calcium chloride. Water vapor joins these compounds as a liquid, thus liberating its enthalpy of vaporization and causing the air stream to leave at increased temperature. This becomes practical only when the greater percentage of moisture has already been removed by compression and cooling.

Flow Rate Control

In general the best flow control is achieved when the operating pressure is less than 53 percent of the storage pressure. This means that sonic velocity, which varies only with temperature as previously noted, will be maintained and steady flow will occur regardless of the fact that the reservoir pressure is dropping. However, when the reservoir pressure has dropped to below 1.89 times the operating pressure, then a continued drop will give a varying flow rate. Also, the higher the operating pressure becomes, the greater becomes the weight flow of air for a given pressure differential and orifice size. Thus, it becomes obvious that when the same weight flow of air is required to do a given amount of work regardless of the operating pressure, then there must be a decrease in orifice area with an increase of pressure. This decrease soon approaches the impractical for very high pressures because manufacturing tolerances become prohibitive.

The relationships governing weight of flow depend on whether the air is considered "compressible" or "non-compressible". In orifice design, the air is considered "non-compressible" when $P_1 - P_2 < 0.0025\ P_1$ and "compressible" when $P_1 - P_2 > 0.0025\ P_1$. The flow equations are given in Table I. Fliegner gives the empirical equation for a smooth, well-rounded orifice of $\frac{1}{8}$ to $\frac{1}{2}$ in. thickness with a corner radius of $\frac{1}{16}$ in. less than the thickness, as follows:

$$W_F = 0.53\ A\ \frac{P}{\sqrt{T}} \qquad \text{when } P_1 > 1.89\ P_2 \tag{9}$$

$$W_F = 1.06\ A \sqrt{\frac{P_2 P_1 - P_2}{T_1}} \qquad \text{when } P_1 < 1.89\ P_2 \tag{10}$$

The choice of orifice types also depends on the ratio of initial pressure to back pressure. For conditions *A* and *B* shown in Fig. 5, a converging nozzle is recommended; for condition *C* a diverging type should be specified. Sharp edge orifices or square orifices are the simplest to produce, but require calibration to determine the actual orifice area because the necking down or "vena contracta" occurs beyond the orifice plate itself.

An excellent treatise on orifices is given in the *ASME Transactions* on "Flow Measurement" and "Fluid Meters."

Valve Limitations and Operating Hazards

At high pressures, the same difficulty of manufacture (and operation) extends to the valves used to control

Table 1—Formulas for Flow Through Nozzles and Orifices[1]

Flow Through Nozzles and Venturi Meters

$$W_F = \frac{C_v Y A_2 w_1 E}{\sqrt{1 - \frac{A_2^2}{A_1^2}}} \sqrt{\frac{2g\,(P_1 - P_2)}{w_1}}$$

Flow Through Sharp-Edged Orifices

$$W_F = \frac{C_v C_c A w_1 Y E}{\sqrt{1 - C_c^2 \frac{A^2}{A_1^2}}} \sqrt{\frac{2g\,(P_1 - P_2)}{w_1}}$$

Where W_F = weight flow in lbs/sec.
C_v = coefficient of velocity
C_c = coefficient of contraction (empirical)
A = orifice area in sq ft
(A_1 = inlet area)
(A_2 = throat area)
w_1 = lb/cu ft (weight of fluid $= \frac{P}{RT}$)

$$Y = \sqrt{\frac{1 - \left(\frac{A_2}{A_1}\right)^2 \frac{K}{K-1} \left(\frac{P_2}{P_1}\right)^{2/K} \left[1 - \left(\frac{P_2}{P_1}\right)^{(K-1)/K}\right]}{\left[1 - \left(\frac{A_2}{A_1}\right)^2 \left(\frac{P_2}{P_1}\right)^{2/K}\right] \left(1 - \frac{P_2}{P_1}\right)}}$$

E = area multiplier based on expansion or contraction of the orifice due to heat and pressure.
P_1 = inlet pressure
P_2 = outlet pressure

[1] For curve of Y expansion factor for air, see *ASME Transactions on Flow Measurement.*

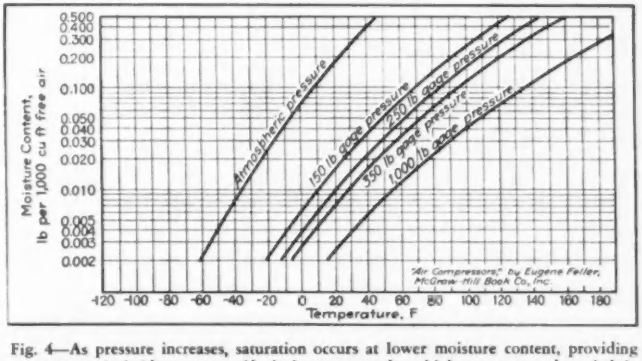

Fig. 4—As pressure increases, saturation occurs at lower moisture content, providing temperature is held constant. If air is compressed to high pressure and cooled in an intercooler, the amount of moisture in air is materially less.

the actuating units as with certain other system components. This is caused by the fact that for high pressures, line sizes are small and control valves approach the point where it is not practical to build the parts as small as permitted by the flow requirements. It is necessary to build them larger, and the larger parts subjected to high pressure require a large operating force. This may be accomplished by applying greater force manually, or by using electric solenoid or pilot control valves—at a sacrifice in weight.

The limitations of pressure have to be determined by the entropy, enthalpy, and the temperature characteristics of air as well as by the development of control valves and equipment for the purpose. Only time and the ingenuity of the designers will finally fix the limits. For aircraft, the present limit would appear to be 3000 psi.

Conclusions

The advantages and limitations of high pressure systems have insofar as is practical, been covered by previous discussions. There are of course, other considerations that must be taken into account by the designer; for example, as pipe size decreases due to higher pressures—assuming equivalent high velocity flow—friction loss increases in far more rapid proportion, but nothing more can be done here than simply mention that the problem exists.

In projecting the design of a high pressure system, the factors to be determined are as follows:

1. The required speed of operation and the forces necessary to obtain that speed.

2. The operating pressure to be used, with the following items being given preference in the order that they most affect the design of the particular system.

Compressor availability—weight, size, output pressure and capacity.

Number of cycles of operation required without recharging the reservoir, and from this, the reservoir size.

Weight and size of the operating units as determined by the operating pressure.

Method of removing moisture to eliminate hazards such as erosion, corrosion and freezing, plus loss of work.

Practicability and cost of manufacture of parts as well as cost of material to be used.

Operating temperatures to which the system will be subjected.

Probabilities of leakage of air from the system due to high pressures.

The line size based on the maximum allowable pressure loss due to friction.

3. The absolute minimum distance of the reservoir from the operating units. This is one of the important features of an aircraft pneumatic system. Not only is the landing gear used to store compressed air for actuation, but it also makes possible an exceptionally short supply line to the actuating cylinder, thereby reducing line loss to a minimum. In addition, return lines beyond the selector valve are unnecessary.

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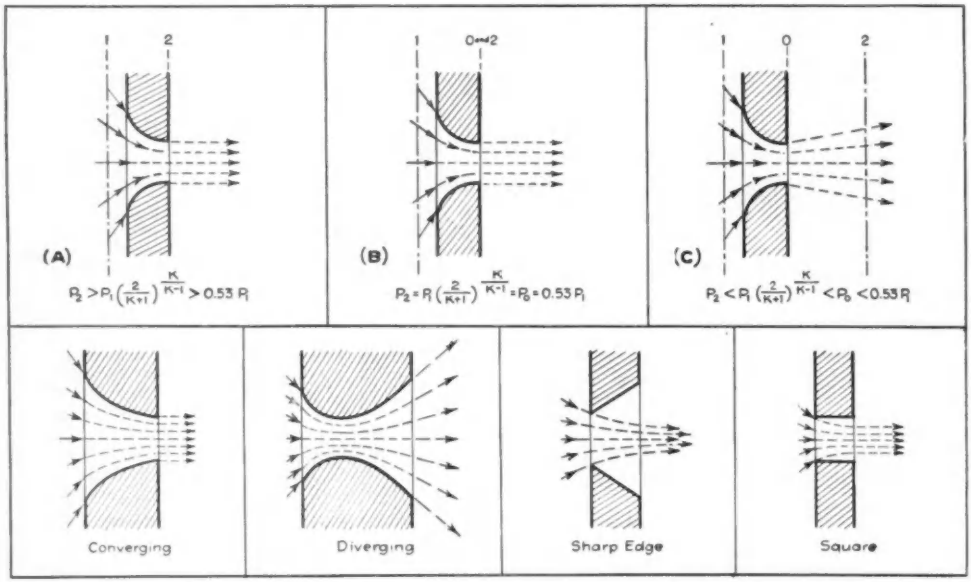

Fig. 5—Conditions governing orifice selection. Converging orifices are used when the discharge pressure is less than or equal to 0.53 multiplied by the back pressure, and diverging orifices, when the discharge pressure is greater. Sharp edge or square orifices are satisfactory in some instances and are cheap to make, but must be calibrated to determine throat affect.

Modified SR-4 Indicator To Measure Dynamic Strains

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Texas A. & M. College

NUMEROUS SYSTEMS for measuring dynamic strains with bonded resistance wire strain gages have been devised, but most, if not all, of these require highly complex, specialized equipment.[1] An inexpensive and simple solution to the problem is to modify the standard SR-4 static strain indicator and use it in conjunction with a cathode-ray oscilloscope. The difference in complexity between this equipment and an ordinary dynamic strain measurement system is illustrated in Fig. 1.

The basic requirements for a dynamic strain measuring bridge are assembled in the static strain indicator. However, the output from the oscillator in this indicator contains an appreciable amount of second harmonic, which becomes objectionable at balance because the cathode-ray oscilloscope indicates deflections when there are none. This difficulty can be solved by the addition of a twin-T circuit between the indicator and the oscilloscope.

Before constructing the twin-T circuit, it is necessary to measure the fundamental frequency of the oscillator in the SR-4 indicator. This can be accomplished by using the cathode-ray oscilloscope and a calibrated oscillator. By observing the Lissajou figures (wave patterns) that are obtained on the oscilloscope when two signals of different frequencies are applied, information as to the relative frequencies and magnitudes of the signals can be obtained.

In one particular case, the oscillator frequency was 945 cps. For simplicity, a balanced twin-T circuit was constructed to have a null frequency of 1890 cps, with a ratio of $\frac{1}{2}$ between the shunt and series elements. This circuit is shown in Fig. 2. The value of C_1 was 670 μf, although any reasonable value of capacitance can be used provided the necessary relations given in Fig. 2 are satisfied. The blocking condenser should have a value of 0.001 μf. The twin-T circuit is connected between grid and ground of the last amplifier stage (pins 5 and 2 of the 1G6-6T vacuum tube nearest the front panel) of the SR-4 indicator.

A variable condenser such as shown in Fig. 3 should be added to the system if there is an appreciable amount of capacitive unbalance in the leads to the strain gages. This condenser has a variable capacitance consisting of a two-gang 365 μf variable condenser, such as is used in small radios, plus a fixed capacitance of 670 μf. A toggle switch allows the latter to be connected in parallel with the variable condenser.

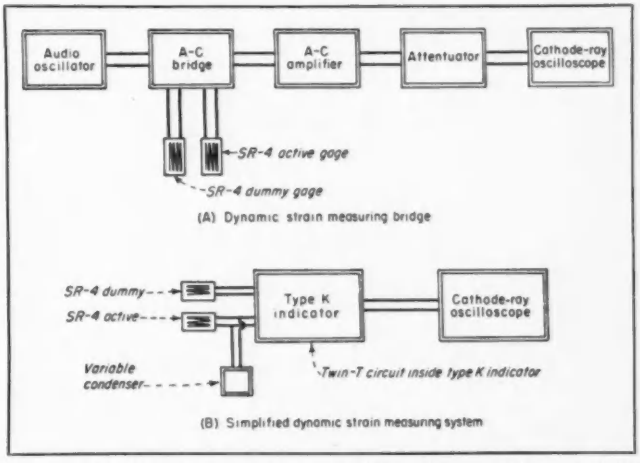

Fig. 1—Comparison of conventional system, (A), and system using a modified static strain indicator, (B), for measuring dynamic strain. For the former system, several expensive and complex elements are required, while for the latter, only devices that are standard in the ordinary test laboratory are necessary.

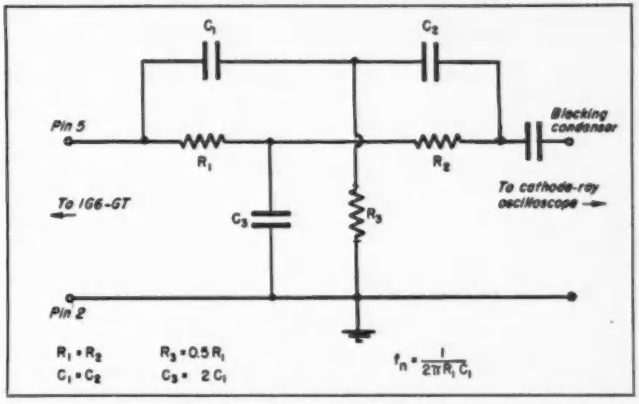

Fig. 2—Twin-T circuit that is added to the static strain indicator to filter out the second harmonic of the oscillator. Otherwise, such harmonics would be indicated as deflections on the oscilloscope. In the formula for f_n, the null frequency in cps, R_1 is the resistance in ohms and C_1 the capacitance in farads.

Strain Measurements

Information relative to gage mounting techniques and active and dummy

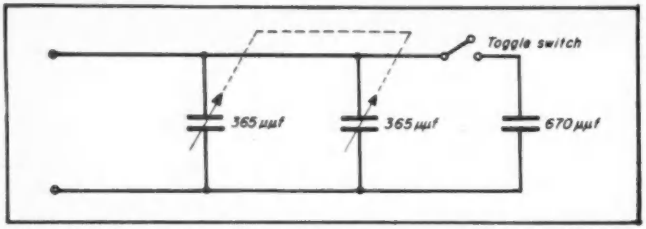

Fig. 3—A variable condenser, such as is indicated here, may be necessary if there is appreciable capacitive unbalance in the leads to the strain gages.

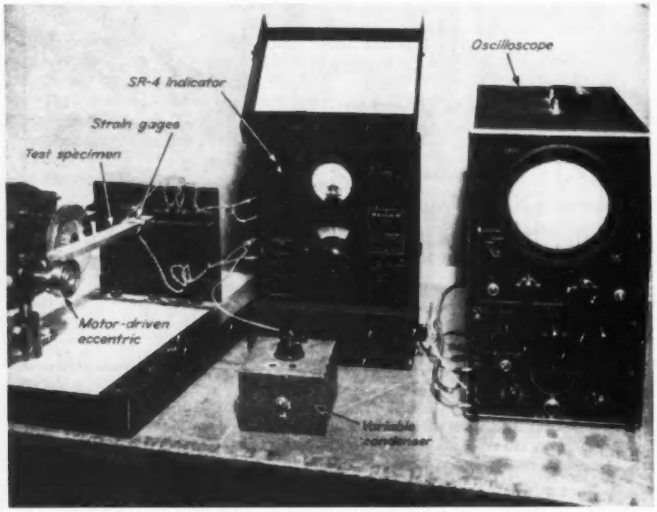

Fig. 4—Set-up for inducing and measuring dynamic strains in a test specimen.

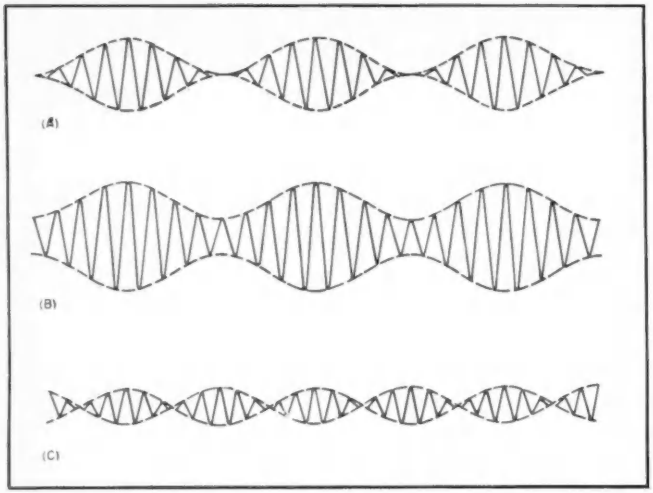

Fig. 5—Wave forms obtained on the oscilloscope: (A) sinusoidal strain in one direction (tension or compression, not both); (B) sinusoidal strain superimposed on a static strain; and (C) sinusoidal strain in two directions (tension and compression alternately).

gage alignments may be found in the references[2, 4]. The measurements described herein were made on a bending specimen using the dummy gage as an active gage. Dynamic bending strains were induced by a motor driven eccentric, as shown in Fig. 4. Using such equipment the indicator is turned on and initial balance is obtained by the usual method for static strain measurement—by varying the internal resistances to produce a balance with the external resistances. Then the cathode-ray oscilloscope is turned on and the gain increased to maximum while adjusting the variable condenser for minimum deflection. This balances out the unequal capacitances in the leads to the strain gages. If no minimum deflection is obtained, the variable condenser is connected to the terminals of the other strain gage and the adjustments are repeated exactly as they were before.

The oscilloscope may be calibrated by observing the change in vertical deflection for a given amount of unbalance in the indicator. This will permit readings to be taken from the screen of the oscilloscope. As will be pointed out later, they may be taken more accurately on the dial of the indicator. The maximum sensitivity obtainable with this set-up is 300 micro-inches per in. of vertical gain when using a Dumont Model 208 oscilloscope.

The dynamic strain is then applied and the gain, and sweep frequency controls on the oscilloscope are adjusted to give a stationary picture of convenient dimensions. The pattern obtained will be a 945 cps sine wave modulated by the strain. The sweep frequency should be a sub-multiple of the modulating frequency, thus showing several cycles. It will show both the static and the alternating component of the strain. For example, a sinusoidal strain in one direction from the equilibrium position (tension or compression, not both) would produce the pattern shown in Fig. 5(*A*). A sinusoidal strain superimposed on a static strain would result in the pattern of Fig. 5(*B*). A sinusodial strain in both directions from the equilibrium position (compression and tension alternately) would result in the pattern of Fig. 5(*C*).

Having observed the wave form of the strain on the screen, measurements of the magnitude of strain can be made from the indicator while observing the oscilloscope. Consider a strain having both an alternating and a direct component such as Fig. 5(*B*). By turning the balance knob on the indicator, the amplitude of the pattern will decrease until the top and bottom out-

line of the pattern touch at some point such as Fig. 5(*A*). The gain control of the oscilloscope may be progressively increased, maintaining a convenient amplitude. At this point, the reading of the indicator should be recorded. This can be considered the static strain, if desired, with the alternating strain super-imposed as an increasing strain. If the balance knob on the indicator be turned further in the same direction, a pattern corresponding to Fig. 5(*C*) will appear and the balance indicator on the SR-4 will indicate zero strain. The reading on the indicator at this point gives the average strain upon which the alternating strain is super-imposed, in both plus and minus directions. As the balance knob is turned further, the outline of the pattern will again separate at some point. The reading of the indicator should again be recorded and the difference between this reading and the one obtained when the pattern was first made to touch, gives the peak to peak (max to min) value of the alternating component of strain. The readings may be taken directly from the screen of the oscilloscope if the screen has been calibrated as explained previously.

It is to be noted that the addition of the twin-T circuit does not affect the use of the SR-4 indicator for measuring static strains.

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New Laboratory Wear Test for Gear Lubricants

RECENT INVESTIGATIONS at the National Bureau of Standards have shown that the SAE extreme-pressure lubricants testing machine can be adapted to measure accurately the wear obtained with various automotive gear lubricants under simulated service conditions. This apparatus—originally designed for testing load-carrying capacity of gear lubricants under fixed high-speed and shock-loading—provides a sensitive means for the evaluation of lubricants with respect to wear at high torque and low-speed operation. The new test therefore makes it possible to detect any significant difference in the performance of lubricants meeting the requirements of the same specifications.

Of the various laboratory testing machines commonly used in the study of automotive gear lubricants, the SAE machine more nearly simulates actual gear operation. Two contacting cylindrical test cups of this machine are rotated at different speeds under load, providing a combined rubbing and rolling action that is typical of leaded gear teeth. A further similarity is a constantly changing line contact with respect to the surfaces of both cups, hence no one point on the periphery is under continuous stress.

The machine is particularly adaptable for wear tests because the test specimens are of such size and shape that accurate indications of wear may be obtained by determination of loss in weight. Also, any wear that occurs on the test cups does not materially affect the area of contact under a given load. On the other hand, the method of lubricating the test surfaces is not especially suitable for long-time tests, and it was necessary to modify the machine in this respect.

Although the primary objective in modifying the lubrication system was long-time operation, it was decided also to provide better temperature control of the upper test cup. In the original machine, the lower test cup is supported half immersed in a small oil box. Lubrication between the two cups is affected by oil carried up as the lower cup rotates. Since only the lower cup is cooled by immersion in the oil bath, the upper cup runs at a considerably higher temperature. This is usually quite noticeable in the load-carrying capacity tests. For this reason, an additional oil reservoir of larger capacity and a circulating system were provided for the upper cup.

In the modified lubrication system, the oil being tested is drawn from a reservoir by a motor driven pump and delivered through a ¼-in. pipe to the top of the upper test cup that is covered by a special oil splash guard. The oil then drains to the oil box, which is fitted with two ¼-in. overflow pipes so located that the oil level in the box partially immerses the lower test cup. The oil from the overflow falls into open fittings in a ¾-in. drain pipe and returns to the reservoir. Heat is applied to the oil reservoir and delivery pipe, while thermocouples in the oil box and oil reservoir provide a means for temperature measurement and control.

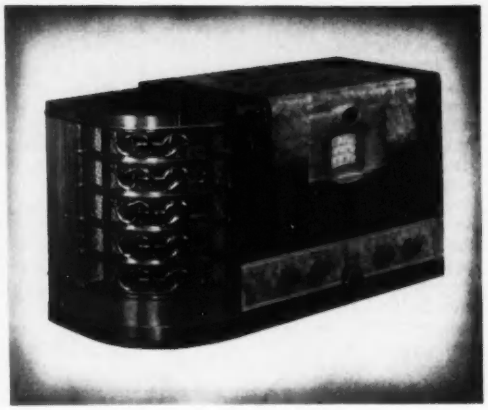
The lubricants used in the Bureau's investigations were SAE 90 grade and included a Navy contract 1080 mineral oil, five lubricants conforming to U. S. Army Specification 2-105B, five lubricants conforming to Federal Specification VV-L-761 and one lead-soap active-sulfur lubricant.

In these wear tests, the upper cup is driven at a speed of 500 rpm with a 3.4 to 1 gear ratio between the upper and lower cups, thus providing a 2.4 to 1 ratio of rubbing to rolling at the contacting surfaces. The specimens, steel Timken test cups, have an average (root mean square) surface roughness of from 25 to 30 microinches as measured with a Profilometer. Each lubricant sample (two quarts) is circulated at a rate of about 500 grams per minute. With a constant oil temperature of 225 F, tests were made at constant scale loads of 90, 135, 180 and 225 pounds. The loading system is such that the corresponding loads on the 2-in. dia by ½-in. test cups are ten times the scale readings. Tests were also made at 250 F and 180-lb load. The above conditions approximate the range of conditions covered in the usual high-torque low-speed gear tests.

The test cups are weighed before and after each period of operation, the loss in weight being used as a measure of wear during the test period. At the beginning of the investigations, weighings were made at frequent intervals and the tests were run for as long as 75 hours. It was found, however, that representative data could be obtained by operating for about 25 hours, with weighing after 4, 11, 18 and 25 hours of operation.

The data obtained in these tests indicate that there is a run-in period of high rate of wear for a few hours, after which the wear settles down to a fairly constant rate. In a graphic plot of such data, the straight portion of the curve usually is well established by 25 hours of operation. The slope of this portion of the curve is more significant from the standpoint of estimating gear life than the observed loss in weight for any given length of time.

1 GOOD DESIGN has pleasing proportions. Rounded end gives movement. Lines flowing from side around to front are harmonious with the rectangular shape; circular knobs harmonize with circular speaker. Variety is achieved by wavy lines on cloth grill and radio name at oblique angle. Such lines are best incorporated in the plastic.

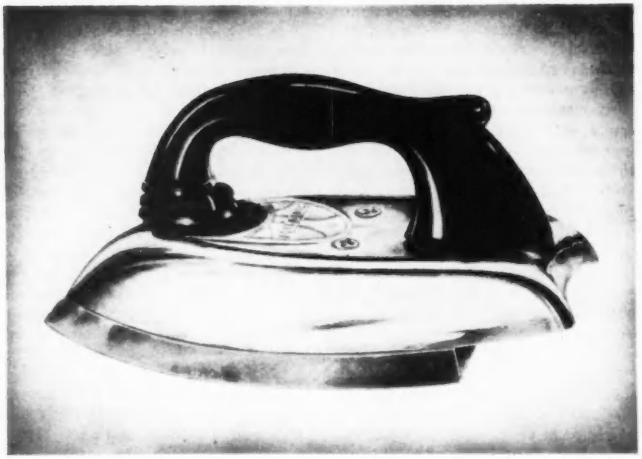


2 POOR DESIGN comes from lack of harmony or rhythm. This radio appears to consist of two separate units, since there is no connecting theme between the speaker section and radio cabinet. Although interesting textures are present, there are too many centers of interest, causing the eye to rove without settling on a focal point.

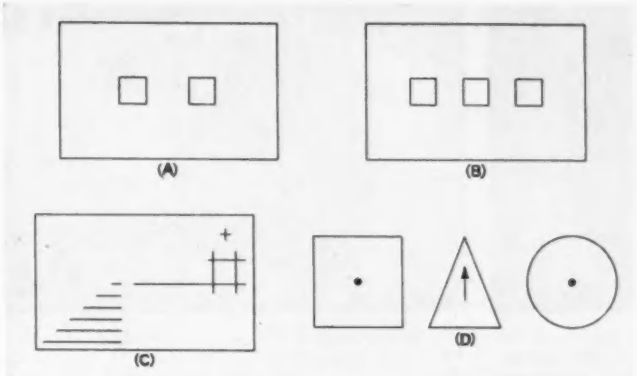
External Design Factors

What makes a "good" or pleasing external design? The answer is a judicious combination of basic design principles: Balance, rhythm, emphasis, harmony and variety, texture and color. Shown here are examples that illustrate successful and unsuccessful attempts

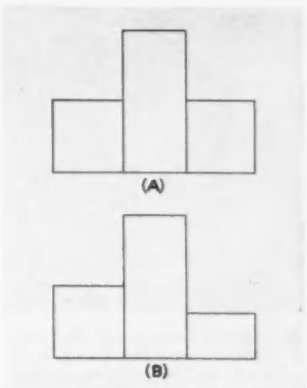
5 FUNCTIONAL DESIGN often dictates whether balance is to be formal or informal. Formal balance of microphone about the vertical axis fits in with the stand, which serves a useful purpose. This type of balance suggests equilibrium or stability.



6 RHYTHM, or "flow", is determined by dominant lines of the product. These lines can appear as grooves, beads, reeds, louvres, bars, or simply painted lines. They are usually milled or ground into the mold, or can be incorporated in the hob that is sometimes used to produce cavities in the mold. The rhythm can be simple or intricate; simplicity is the theme of this iron handle, which can be considered as a single line, with the eye moving up and around the handle, and returning to the base.



3 EYE MOVEMENT on a predetermined path is one test of a successful design. In *A*, eye moves from one square to the other without coming to rest. In *B*, eye moves from one side to the other, and comes to rest in center square. In *C*, eye moves diagonally; long horizontal line in center prevents eye from jumping between two designs. *D* contrasts monotonous shapes, square and circle. with a "moving" shape, a triangle, in which the eye moves toward the smallest angle.



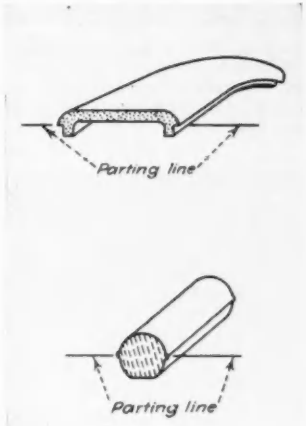
4 BALANCED DESIGN. In *A*, there is formal balance about the vertical axis. It is often used because the molds are simpler, resulting in reduced costs. The informal balance in *B* is finding favor with designers.

in Molded Plastic Products

at utilizing these principles in molded plastic products. Characteristics of the molding process should be utilized in good part design.

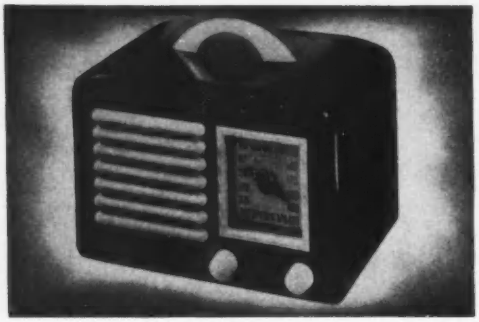
D. W. BIKLEN

Product Engineer, DeBell and Richardson

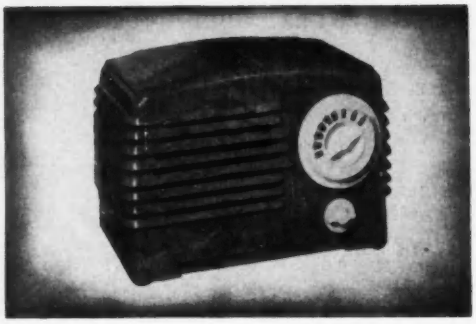


7 PARTING LINE of the mold, often the source of an unsightly flash line can be utilized as a line of rhythm. Flash can be removed with a simple file stroke. Shown here are two good methods of utilizing the parting line for rhythm.

8 BEADS AND GROOVES are excellent methods of disguising misalignment between mold halves (parting line); these can be machined or hobbed into the mold cavity. The telephone handset has a bead along the parting line. In the iron handle, a V-type groove made with a cutting tool in the finishing operation, completely eliminates the flash line. Rear section of the handle contains a large bead. Thus, an objectionable parting line is transformed into a pleasant line that follows the contour of the part.

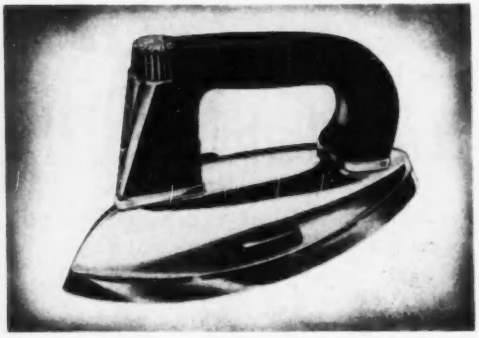


9 ABRUPT CHANGE of rhythm and static appearance (not to be confused with formal balance) are two characteristics of poor design. Lines on this radio have minimum "flow". Although there is not room enough for three knobs, a small circular white trade mark between two knobs might have served as a focal point for emphasis or interest.



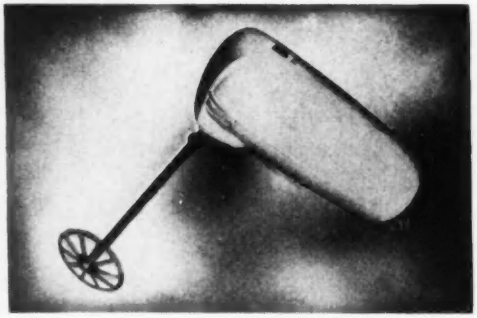
10 SMOOTH TRANSITION, as eye is led around this radio via the grilled section, is responsible for graceful appearance. Louvres change direction 90 deg, yet there is no feeling of abruptness, as in radio at left. Informal balance is achieved by placing the large dial on one side, without throwing the overall design out of balance.

11 INCOHERENT EFFECT of this electric steam iron stems from lack of emphasis. The eye jumps back and forth between the knob on top and the heat regulator. Although the knob is functional, serving as an entrance for water, it might have been made less conspicuous.



12 BETTER DESIGN is achieved by recessing control knob into handle of electric iron. Metal piece, running from base to knob and containing name of maker, is the single point af emphasis. It also helps maintain rhythm by leading eye around the handle.

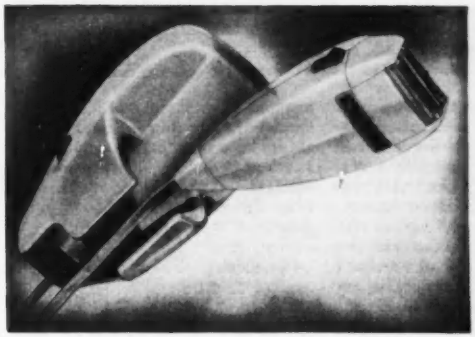
15 FUNCTION should be combined with flow for good design. Upper pot handle, although serving a useful purpose, lacks smoothness. Curved pot handle below has smooth functional "bumps" molded in, and weighs about the same. Mold costs are similar, proving that a pleasing design does not mean greater unit costs than a crude design.



16 FLOW combined with function makes this portable food mixer an attractive product. Rhythm is achieved through the raised portion, which runs from the rear top around and down the front section. Function of the housing—to hold the motor that drives the agitator—is not compromised by the graceful lines that are molded in.

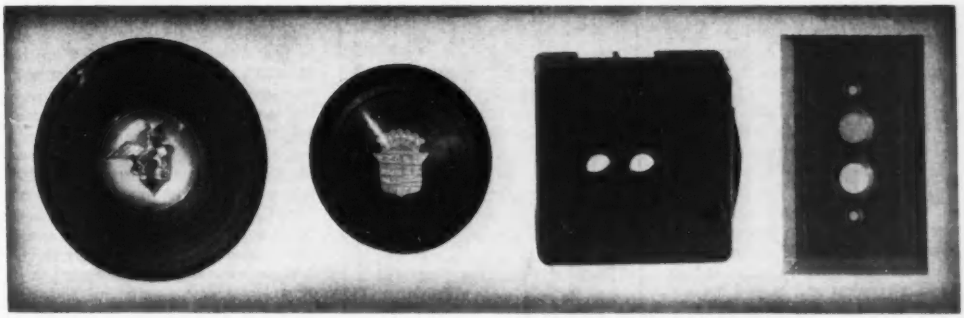
How to Utilize Design Principles

Design Principle	Effect	Fig. No.	How Accomplished
Proportion	Solid or substantial feeling	1	For rectangles, maintain correct ratio of small side to large side (1:1.10 to 1:1.75). Keep important sections related in size and shape; avoid sharp contrast in major sections.
Formal Balance	Formality or dignity	4(A)	Maintain symmetrical design about the vertical or horizontal centerline.
Informal Balance	Movement	4(B)	Maintain unsymmetrical design about the vertical or horizontal centerline.
Rhythm	Controls movement of eye about part	10	Grooves, beads, louvres, lines and bars.
Emphasis	Strongest attraction for eye	13	Trademarks, abrupt change of shape, contrasting color.
Harmony	Pleasing and restful	14	Smooth surfaces, straight parallel lines, ribs, louvres, gentle curved surfaces.
Variety	Interest or curiosity	12	Surface decorations, varying colors, lines, ribs, louvres, curved parallel lines, or a series of angles.
Texture	Adds interest	17	Use of mottled colored plastics, straight knurl, leather finish, satin finish, and other special effects.
Color	Gives "life" or functional feeling	17	Correct choice of color or combination of colors.



13 FOCAL POINT of trademark gives emphasis to the product. If a part is so designed that the eye fails to find a final resting place, or there is a scattered effect caused by parts competing for attention, a lack of emphasis results. Trademarks can be incorporated in the mold.

14 NAMEPLATE serves a center of emphasis or interest. Additional features of this molded plastic scale housing are gentle curved surfaces which contribute to harmony; the smooth design also makes cleaning easy. White gives impression of cleanliness.



17 COLOR AND TEXTURE add interest to a product. Car horn buttons, molded in transparent acrylics, are appealing because of the color combinations that can be achieved by painting, plating, or use of opaque colors behind the transparent section. Special psychological effects, such as warmth or cleanliness, can be obtained by choosing the proper color combination. Surface texture can be varied in plastic products; a smooth, slick finish can become monotonous. A leathery texture, as shown in the colorimeter housing, fine straight knurl of the switch plate, and many other interesting surface effects can be obtained by sandblasting, hand punching, or hobbing the mold cavity.

Internal Stresses in Dimensionally Stabilized Steel

From "Internal Stresses in Hardened and Dimensionally Stabilized Steel" by L. W. Nickols, B.Sc. (Eng.), A.M.I.Mech.E., A.M.I.P.E., *Aircraft Production*, March, 1949, page 103.

HARDENED STEEL in the quenched condition is not dimensionally stable. It is commonly thought that the gradual changes in size with the passage of time are caused by the slow relief of internal stresses introduced during quenching, and that a stabilizing process following quench relieves these stresses completely.

Experiments carried out in the Metrology Division of the National Physical Laboratory prove that there are still considerable residual stresses locked up in hardened and stabilized steels. This experiment made use of the fact that any stresses present in a hardened and stabilized material must necessarily be in a state of balance. A suitable machining operation on the material will remove some of the stressed material, causing a movement of the remaining material until a state of balance is again attained.

A bar of cicular section was selected for the experiment, as the longitudinal stress distribution over any normal cross-section of such a bar is theoretically symmetrical with respect to its longitudinal axis, and is likely to be so if adequate care is taken during the heat treatment. The bar, 1 in. in dia and 10 in. in length, of 0.9 percent carbon tool steel, was machined all over and then hardened throughout by heating to 770 C and quenching in oil. Care was taken during heating to get as uniform a temperature as possible throughout the bar, and the quenching operation was carried out with the axis vertical. The piece was then stabilized by heating to a temperature of 150 C for ten hours and allowed to cool slowly in the furnace. Past experience has shown that this process is completely satisfactory in producing dimensional stability. The circumference of the bar was finish-ground and its end faces ground and lapped flat and parallel to a high degree of accuracy. The diameter and length of the bar were then measured.

Progressive amounts of metal were next ground carefully and uniformly off the circumference of the bar, and the length and diameter were remeasured after each removal. The length of the bar was found to decrease nearly uniformly with the reduction in diameter. Fig. 1 shows this decrease.

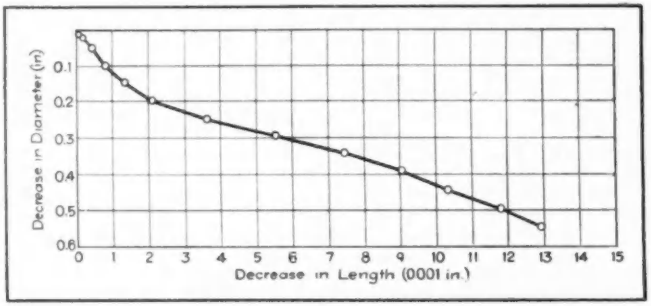


Fig. 1—Progressive reduction in length of bar is nearly uniform as diameter of test specimen is decreased. Measurements were made after successive grinds.

The results indicate clearly that the stabilizing operation did not remove the internal stresses set up in the quenching operation, otherwise the length of the bar would have remained unaltered despite the changes in diameter, and that presumably dimensional instability is caused mainly by changes in structure of the steel. The decrease in length of the bar with progressive reduction in diameter indicated that there was a compressive stress toward the outside of the bar and tensile stress at the center.

From a knowledge of the diametral amounts of metal removed and the consequent reductions in length of the bar, the initial stresses in each of the layers removed were calculated using the formula developed by Heyn and Bauer (*Internationale Zeitschrift fur Metallographie*, I-20, 1911), in which

f = average initial stress in layer of metal removed, psi
E = Young's Modulus, 30×10^6, psi
l = original length of bar, in.
l_1 = length of bar before removal of layer, in.
l_2 = length of bar after removal of layer, in.
A_1 = area of cross section of bar before removal of layer, sq in.
A_2 = area of cross-section of bar after removal of layer, sq in.

$$f = E\,\frac{A_2(l_2 - l) - A_1(l_1 - l)}{l(A_1 - A_2)}$$

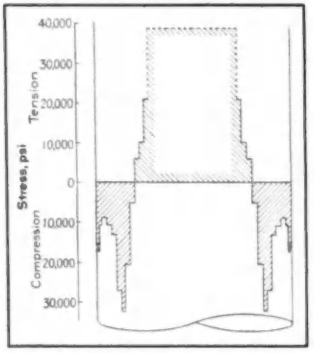


Fig. 2 — Calculated stress-distribution over diametral section of bar shows peak compressive stress occurs at an appreciable depth.

The above formula is based on the assumption that only longitudinal stresses are present in the material—the radial and circumferential stresses are zero.

Values of the stresses obtained are plotted in Fig. 2 and it will be observed that a maximum compressive stress of 32,000 psi was obtained at an appreciable depth. It was not found possible to reduce the diameter of the bar below 0.46 in. because of the increasing lack of rigidity. The average initial stress across the remaining section of the bar was calculated, therefore, by assuming that the difference between the total compression and tensile loads in the progressive layers removed from the bar acted over the final cross-section of the bar; that is, in its initial stabilized

condition, the total compression and tensile loads in the bar were equal.

Total compression load in the stabilized bar amounted to approximately 7,900 pounds. The bar is still dimensionally stable despite the removal of approximately 0.54 in. from the original diameter of 1 inch. Measurements of the length over a period of four months immediately following the final machining operation showed that there was no change during this time in the overall length to within the limits of accuracy of measurement.

That the internal stresses in a hardened and stabilized bar are still present after a considerable period of time was proved by the alteration in length of a hardened and stabilized bar, 1 in. in diameter and 9 in. in length, of high-duty cast iron, when successive layers were removed from the circumference. This bar had been under observation for a period of nine years before the test. The total change in length during this time was nil, to within the limits of accuracy of the measurement. Removal of 0.05 in. on the diameter produced an increase in length of 0.0007 in., this being equivalent to initial tensile stress of 23,000 psi in the layer of metal removed. The reason for the stress at the outer surface of this bar being tensile, instead of compressive as for the steel bar, is not known, but was probably caused by the quenching operating. Details of this operation for the cast-iron bar were not known.

Trends In Gear Design

Foreign Abstract Condensed from "Trends in Gearing" by Harry Walker, *The Engineer*, March 18, 1949.

THIS ARTICLE is a summarization of some of the tendencies in gear design that have for their object the securing of the best gear performance with minimum dimensions. Most new information is obtained from applications in which (1) large quantities of gears of one size are used; (2) those where loads and speeds are carried to extremes and weight has to be kept down; (3) those where consistently successful results are more important than the cost of attaining them.

Distortion as a Factor in Gear Design

A clear tendency in gear design has arisen with realization that gearing is no longer a purely kinematical problem. The elasticity of gears, bearings and housings has in recent years become a factor in gear design. Better machining processes have increased the accuracy of gear production, but elasticity has remained constant. Therefore the equivalent errors due to distortion under load can be greater than the actual production errors in the gears. At the present time an endeavor is being made to produce and mount heavily-loaded gears in such a way that they fulfill the requirements of uniform angular velocity transmission and best distribution of contact loading, in the shape and position that they assume when distorted by the load.

Greater rigidity of mounting has also been attained, but only to a limited extent because of the increased weight. For spur gears the angular lag of the driven gear can be made constant for a given rate of loading, thus restoring uniform angular velocity transmission and eliminating dynamic overloads by modifying the involute profiles. Modification consists of a departure inside the true involute, starting at a point just above the pitch line on both gears. It has been found that tooth deflection is proportional to load per unit face width and is independent of the pitch of the teeth. It has been shown that the modification to the involute profile should start with each end of that part of the tooth action where only one pair of teeth carry the load. An empirical factor for the actual magnitude of the design modification to the teeth has been determined. This empirical constant has been varied by trial and error. There must exist an enormous amount of data which, if it could be collated, ought to lead to a very accurate estimate of the constant.

Torsional deflection and endwise deflection of spur gear teeth also lead to maldistribution of load, which can be corrected by deliberately crossing the axes of the gears at a very slight angle.

The crowning of spur gears is a more recent American introduction. It consists of relieving the teeth towards the two sides of the face width by a very small amount. It is possibly of some use where the gear mounting is not accurately controlled, but on the other hand, it is questionable as to whether it would not do more harm than good on applications where loading is heavy and where care is taken to insure accurate mounting and alignment. On such application crowning is bound to cause higher specific tooth loads which might be the cause of early pitting.

Bevel Gears: There has been an advancement in the direction of allowing for misalignment and for deflection of the gears, shafts, bearings and housings. The method is to produce the gear such that the contact without load on the gears is localized midway, or rather toward the toe of the teeth and clear of both ends of the teeth. Under load, contact spreads towards the large end, but never bears hard on the extremities. The localized contact also allows for some misalignment.

Helical Gears: Heavy specific loading at the tips and roots of the teeth can be corrected by relieving the involute profiles of both pinion and wheel near the tips of the teeth. Unevenness of loading can be corrected so as to give uniform stresses at all points on the line of contact, by making the pressure angles of the two mating gears slightly different, that of the wheel being greater than that of the pinion. A correction to the helix angle is sometimes desirable to allow for torsional deflection.

Worm Gears: The main tendency for deflection is an axial or tilting movement of the wheel, mainly caused by deflection of the bearings and housings. This causes a loss of efficiency and results in some wear on the wheel teeth in such a manner that the no-load contact is initially toward the leading sides for both directions of rotation.

Comparison of Gear Types

This section of the paper examines the comparative effects of distortion on each type of gearing.

Where modification for distortion is carried out to give a localized contact as in bevel gears and worm gears, the line of contact theoretically becomes a point. There is some loss of contact on bevel and worm gears which are corrected for distortion. Furthermore, the contact floats according to the torque transmitted, because the amount of deflection varies under different loads.

With spur gears there is no loss of length of line of contact after modification for distortion, but modification can only be made to give uniform angular velocity transmission for one rate of loading.

None of these restrictions occurs with helical gears. These retain their full theoretical line of contact when corrected for distortion, and they will transmit uniform angular velocity under any conditions of load. Any

wear which takes place cannot destroy uniformity of motion; in fact, it tends to equalize the stress/wear balance along the line of action. Any wear which takes place on spur gears is always detrimental. For these and other reasons, it is likely that helical gears will come into more general use in place of spur gears.

Pressure Angle

There is a clear tendency towards an increase in the pressure angle gears, even above the present standard of 20 deg. In practice the highest pressure angle which can be used, consistent with a reasonable width, and a working depth sufficient to give ample overlap, is from 24 to 27 deg on normal ratios.

Addendum Correction

This provides a ready means of using those parts of the involute of two mating gears that are likely to give the best performance. There does seem to be a case for a possible future increase in the 20 deg pressure angle adopted for spur gears in the British standard.

There is not yet much practical evidence available as to the effect of pressure angle changes on worm gear performance. As a matter of passing interest not offered in favor of the argument, a pair of worm gears tested by the Government had the highest efficiency ever recorded at a mean normal pressure angle of 27 degrees.

Selection of Machine Tool Transformers

From "Selection of Standardized Machine Tool Transformers" by C. E. Herr, Westinghouse Electric Corporation. Presented at the Thirteenth Machine Tool Forum held by the Westinghouse Electric Corporation, Buffalo, N. Y., April 26–27, 1949.

PROPER SELECTION of machine tool control transformers is necessary for best operation of contactors and relays. The minimum voltage at which contactors or solenoids can be expected to operate is 85 percent of rated voltage. This 15 percent reduction in voltage cannot take place entirely within the transformer with safety since some allowance—about 5 percent—must be made for normal fluctuations in line voltage, for line drop, and for safety factor.

Maximum instantaneous load and maximum continuous load should be figured in selecting the proper size of transformers. Manufacturers can supply values of currents drawn by contactors and solenoids before and after closing. Instantaneous maximum current drawn before closing varies from 3.5 to 15 times the continuous current after the device has closed.

Having determined the maximum continuous load, a tentative kva rating for the control transformer should be selected. Regulation curves of actual control transformers should then be used in determining the size of transformer best adapted for the job. Recommended regulation curves as established by NEMA are shown in Fig. 1. Typical regulation curves of actual transformers are shown in Fig. 2.

Proceeding along a 90 percent voltage line (as assumed above) to the curve for the tentative rating of the control transformer, the percent of rated load that will drop the transformer voltage to this 90 percent voltage is determined. If this value of rated load is at least as great as the ratio of maximum instantaneous current drawn by the contactors and solenoids to their maximum continuous current, the size of transformer tentatively selected will be satisfactory. Otherwise a larger transformer rating will be required so that the maximum instantaneous current will not cause the secondary voltage to drop below the 90 percent value selected.

Normal loads imposed by the contactors and solenoids have low power factors, often on the order of 20 percent. Regulation at 20 percent as set forth in the NEMA curves is much better than for 100 percent power factor loads. Use of lights or any heating or other high-power-factor load operated from the machine-tool transformer raises the power factor and increases the regulation.

Better regulation at the low power factors is apparent in the curves for the new transformers, Fig. 2. It should be noted that all transformers are

Table I—NEMA Recommended Ratings for Specialty Transformers

Primary Voltage Rating, volts	Secondary Voltage Rating, volts	Frequency, cycles	Standard Output Ratings, KVA						
			0.075	0.150	0.300	0.500	0.750	1.0	1.5
220/440	110	60	X	X	X	X	X	X	X
208/220/380/416/440	110/95	50		X	X	X	X	X	X
220/440/550	110	25		X	X	X			

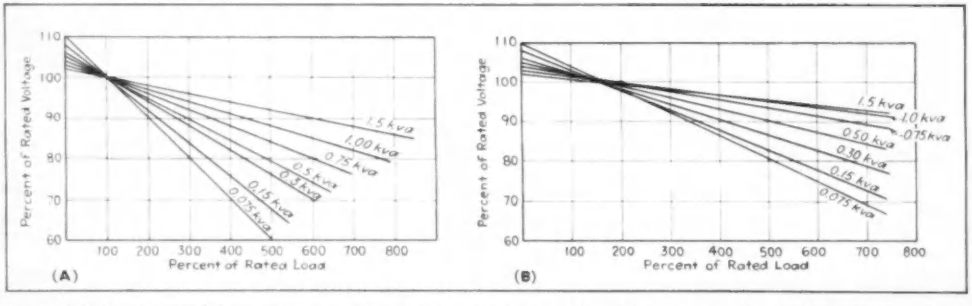


Fig. 1—NEMA recommended regulation curves for speciality transformers (A) at 100 percent load and (B) at 20 percent load.

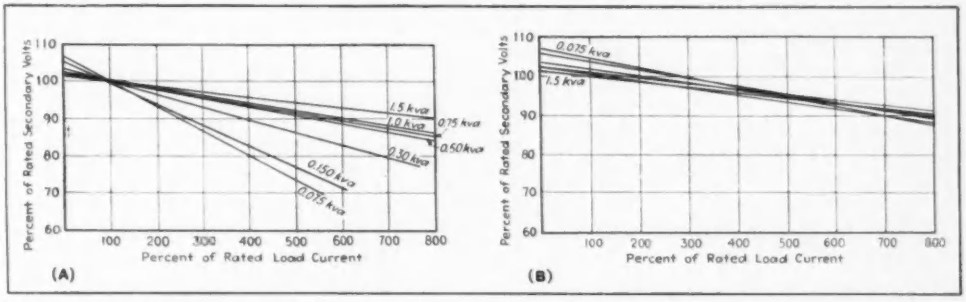


Fig. 2—Actual regulation curves for machine tool transformers (A) at 100 percent rated load and (B) at 20 percent rated load.

capable of maintaining 90 percent voltage at seven times normal current at 20 percent power factor. The no-load voltage does not rise unduly even on the smallest transformer, and the regulation is not widely different. Curves at 20 percent, 50 percent, and 100 percent power factor should give all data normally needed.

Because of the good regulation required of the machine-tool transformer, relatively low impedance is offered so that fault currents are much higher than for transformers with higher impedances. A NEMA recommendation is to furnish a protective device such as a cartridge fuse or a breaker in series with the secondary circuit to protect against these overcurrents.

A number of manufacturers are now offering a special line of transformers having suitable regulation characteristics, and giving regulation curves at both high and low power factors. The proposed standards list transformers in three frequency categories, 60, 50, and 25 cycles. There are seven kva ratings for 60 cycle, five for 50 cycle, and three for 25 cycle frequencies. This data is shown in Table I. The proposed include tests for dielectric strength, heating, and regulation.

Corrosion Losses Through Over-design

From "Costs of Corrosion to the United States" by Herbert H. Uhlig, Massachusetts Institute of Technology, submitted to United Nations Scientific Conference on the Conservation and Utilization of Resources, August 17, 1949.

APPRECIABLE TONNAGES of metal are consumed needlessly each year because equipment is over-designed to take care of corrosion. Because corrosion rates may be unknown, the design engineer often specifies several times the required thickness of metal to insure adequate strength and continued performance. Except for corrosion, the factor of safety might be much less. Over-design is common with construction of reaction vessels, boiler and condenser tubes, buried pipe lines, oil-well sucker rods, water tanks and marine structures.

The magnitude of this factor can be appreciated by reviewing the design of pipe lines carrying natural gas and petroleum. Pipe lines laid without protection are provided with walls exceeding the thickness required for operating pressures. The thicker wall is for the purpose of avoiding early perforation by corrosion from the outside. With adequate external protection, however, the wall thickness can be reduced 20 to 35 percent, still allowing an ample factor of safety with regard to internal pressures. For example, if 225 miles of 8 in. dia pipe can be reduced in wall thickness from 0.322 in. to 0.25 in., 3,700 tons of steel, valued at $330,000 in 1945 can be saved. This saving amounts to as much as or more than the usual combined cost of a protective coating plus cathodic protection.

The reduction of wall thickness also provides a larger internal diameter pipe having approximately 5 percent increase in capacity. This makes possible additional gains over the initial saving of steel. Based on the length of all pipe lines in the country, a 5 percent increase in capacity is equivalent to almost 50,000 miles of pipe.

The large cost of engine wear attributed to corrosion is also startling, but, nevertheless, appears to be correct. Recent experimental data obtained both in England and in the United States proves that piston rings and cylinder walls wear not only by abrasion of one part moving on the other, but also by chemical attack of combustion products. Corrosive wear was found to be especially active during the warming-up period of engine operation when water condenses on the cylinder walls.

Experiments were conducted in 40 to 100 hour tests in which piston rings were weighed before and after, and the internal diameter of cylinders precisely calipered. The conclusive evidence of corrosive wear is briefly as follows:

1. Cylinder-wall temperature of 104 F or 120 F was followed by considerably more wear (in some cases a factor of 5 to 1) than at temperature of 167 F or higher.

2. Using hydrogen as fuel, with low cylinder-wall temperatures, caused substantially less wear than using gasoline or alcohol blends. Combustion products of the latter contain carbonic acid, various organic acids, and sometimes sulphuric acid.

3. Wear increased proportionally to the sulphur content of the fuel.

4. Acids were detected in the combustion products. Sulphuric acid and metal sulphates were detected in cylinder deposits and in used lubricants.

5. Reduction in wear was obtained by use of corrosion-resistant alloys.

6. Substantial reduction in wear was obtained by adding alkaline compounds to oil or fuel, or by passing oil over lime pellets.

The factor of corrosive wear is borne out, as well, by service data. Statistics compiled in England show that cylinder wear for long-distance

runs amounts to about 0.001 in. per 5,000 miles, whereas for automobiles used by doctors and some house-to-house delivery vehicles (more cylinder condensate) the wear was 0.001 in. per 100 to 1,000 miles, a maximum ratio of 50 to 1.

From these and other facts it appears reasonable to estimate that an average of 60 percent of all automobile engine wear can be attributed to corrosion.

As a further example mufflers on automobiles, in the majority of instances, fail by corrosion. There were 4,740,600 mufflers installed by car dealers and independent repair shops in 1948. This does not include mufflers installed at gasoline filling stations, fleet shops, or by individual car owners. The above figure, therefore, multiplied by an estimate $14 for labor and parts gives a conservative estimate of loss from corrosion.

The use of corrosion-resistant metals and alloys is expected to expand because of economies effected by their use. Another factor in this same direction is the increasing acceptance of bright metal surfaces for many decorative applications. The economic advantage of replacing iron by corrosion-resistant metals or alloys is not always realized.

Method for Determining Elastic Moduli

Foreign Abstract condensed from "On Determination of Elastic Constants From Natural Frequencies of Bending Vibration," by Jaakko R. Wuolijoki, published by State Institute for Technical Research, Finland. Helsinki, 1948.

THE USE of overtones in bending vibration of an elastic bar for determining the elastic and shear moduli has proved to be a method easy to carry out if the instruments for causing the bar to vibrate and for observing the phenomenon are available. This method for determining the modulus of elasticity in shear, especially of an anisotropic material, offers greater accuracy than other experimental methods. The numerical treatment of the test results is quite time wasting, however, and complicated, thus making the method unsuitable for research. To remove this disadvantage, a nomographic method for the application of the test results is given.

Charts

It is assured that the bar has a rectangular cross section with the adjoining sides of different lengths. This kind of bar is usually more suitable for the vibration tests than a bar of circular or square cross section, as the frequency of vibration in the direction of the main axes of inertia clearly differs from one another. For the rectangular cross section the numerical factor $\mu = 1, 2$. For practical purposes the ratio of the length of the test specimen to the height of the specimen in the vibration plane, this ratio being the shape quantity determining the frequency, can be restricted to three standard ratios, viz. 100:1, 50:1, and 25:1. The corresponding slenderness ratios are $200\sqrt{3}$, $100\sqrt{3}$ and $50\sqrt{3}$. For each ratio a computation chart can be made, from which for each overtone of vibration an indefinite number of $(U, \omega/V)$-parts of values can be obtained, which comply with the frequency equation derived from Timoshenko's differential equation. These symbols are respectively

$$U = \mu \frac{E}{G} \qquad (1)$$

where

μ = numerical factor peculiar to shearing strain and dependent on shape of cross section.
E = modulus of elasticity in tension and compression.
G = modulus in shear with reference to horizontal and vertical planes perpendicular to plane of vibration.
ω = circular frequency of vibration.

$$V = \sqrt{\frac{2E}{\rho i^2}} \qquad (2)$$

where ρ = mass density of the material
i = gyration radius of cross section.

The charts in Figs. 1, 2, and 3 have been produced for bars in accordance with the ratios mentioned. The graduation of the parameter U comprises the values 0 . . . 20. The order of the vibration has been denoted by v and it comprises in different charts the ranges 1 . . . 20, 1 . . . 14, and 1 . . . 8.

For each sound ω/V-values corresponding to, for instance, in Fig. 2, the values 10, 15 and 20 of U can be obtained. These ω/V-values are divided by ω-values, calculated from f-values by multiplying by 2π. In this way three associated pairs of (U,V)-values are obtained for each sound, which values are marked in the UV-table of co-ordinates and through which a curve is drawn. For the determination of the (U,V)-pairs of values peculiar to the material of the bar, two curves are sufficient, i.e., measuring of two natural vibration frequencies, if it has been carried out carefully and if the orders of frequencies differ enough from each other. By measuring several natural vibration frequencies and by drawing the curves determined by them, an estimate of the accuracy and reliability of the method can be obtained. From the values of U and V determined by the crossing point of the curves, the (E, G)-pair of values is found by means of formula (2).

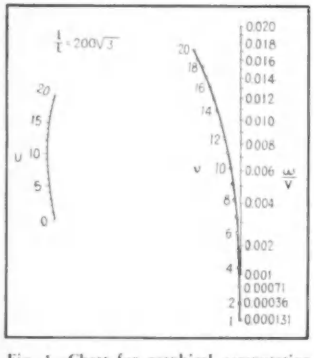


Fig. 1—Chart for graphical computation of $(U, \omega/V)$—pairs of values. Slenderness ratio of the bar 200 √3.

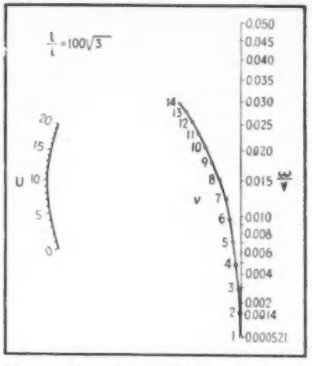


Fig. 2—Chart for graphical computation of $(U, \omega/V)$—pairs of values. Slenderness ratio of the bar 100 √3.

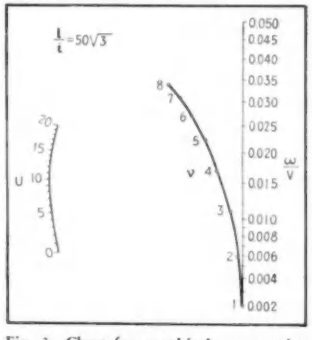


Fig. 3—Chart for graphical computation of $(U, \omega/V)$—pairs of values. Slenderness ratio of the bar 50 √3.

TECHNICAL NEWS

BERYLLIUM-COPPER STRIP is cold-rolled without danger by the Beryllium Corporation. Using no elaborate precautions, this company maintains a clean health record.

Beryllium's Toxicity Is Largely Myth

IN THE PAST FEW MONTHS several magazine articles in the technical press have commited a near libel of the "Beryllium Industry." Well meaning, but overzealous, they have made the metal, beryllium, more dangerous than raw uranium and more deceptive than a king cobra. This is simply not true—here are the facts.

Some chemical *compounds* of beryllium are poisonous. Beryllium fluoride, for example, is very dangerous —but then so is sodium fluoride, so is hydrogen fluoride, so is *any* compound of fluorine when breathed in the form of dust. So, for that matter, is any metal or metallic compound when breathed as dust.

The commercial alloys of beryllium are *not* dangerous under any sane working precautions commonly used with similar metallic compounds. Many plants have been using beryllium alloys for 15 years or more without a single case of poisoning. These same plants were shocked to read that they have been handling a "deadly" alloy.

The greatest popular hue and cry in the so called "beryllium problem" has been in the use of fluorescent lamps. Beginning in 1938, these lamps contained a small amount of beryllium in the form of zinc-beryllium-manganese-silicate. These lamps, when broken in air, gave off a toxic powder that achieved a great deal of publicity in the popular press. It has never been determined whether the small amount of beryllium was toxic or whether the whole compound was toxic because of heat or some other special condition. Public opinion forced the disuse of beryllium in this case. Again it should be noted that zinc-beryllium-manganese-silicate is a chemical compound, and is made from beryllium oxide, another compound. In any case, a metallic dust should not be breathed.

PRODUCT ENGINEERING has gathered information on this subject from a number of sources, and is particularly indebted to Dr. R. H. Harrington, research metallurgist at The General Electric Company, and Mr. Otto T. Englehart, president of the Beryllium Corporation. Another complete source of information is the Saranac Laboratory Symposium of September 30-October 2, 1947. This symposium dealt directly with beryllium and is required reading for anyone needing further confirmation of our viewpoint.

There are three types of disease associated with beryllium compounds. First, there is a form of dermatitis caused by beryllium introduced into cuts when handling the material. This skin rash is at most an annoying "lost time" factor and can be controlled by wearing gloves. The evidence seems to be conclusive that this skin condition is caused by the rather high percentages of fluorine found in some supposedly "pure" metals. There is an acute form of pneumonitis caused by inhalation of beryllium plus an acid radical. Most of these cases show a recovery. Most important, there is a delayed pneumonitis, again caused by the breathing of a dust of beryllium plus an acid radical. There is a high death rate in this last instance.

In all three cases it will be noted that a *chemical* form of beryllium proved dangerous. Many metals form soluble salts, and almost all of them are dangerous. Mercury, lead, barium, copper and silver are examples. The alloys of beryllium are not poisonous. There are only two cases on record of sickness resulting from the use of alloys. Both are the results of improper operation of sulphate pickling baths for the 2 percent beryllium and 98 percent copper alloy. Lack of adequate hoods is a dangerous practice in any metal pickling process and the blame should not, in this case, be laid to a 2 percent solution of beryllium.

Since most writers refer to the "beryllium industry" as a whole, a great deal of damage has been done to those manufacturers who use a safe, useful and desirable material. Not only will this unjust and erroneous publicity cause engineering confusion, but also loss of time and production, and confusion in labor relations.

Beryllium alloys can be safely heat treated, rolled, ground, machined, hot or cold worked or fabricated. Precautions to be taken are usual and not elaborate. As with most compounds of this kind, floors should be swept and mopped to keep down any accumulation of chips and dust. Hoods should be provided for use with abrasive wheels, employees should wear respirators when working with the metallic powder. The same precautions should be taken as those

common in any modern plant handling a metal like, say, copper.

One prominent plant that uses beryllium reports: "During the past twelve years, we have used 80,000 pounds of beryllium-copper strip in thin gages. This has been fabricated into diaphragms or bellows assemblies, leaf springs, etc. During this time, there has been no indication of any health hazard anywhere in our organization caused by beryllium-copper."

Another says: ". . . we were probably the first user of beryllium-copper strip in the country, which was about 1932 . . . since then we have used hundreds of thousands of pounds of beryllium-copper strip, and to our definite knowledge there have been no ill effects from the use of this strip on the people handling either the strip or the parts made from it. We have been aware for some time of the rumors that were floating around and have investigated these. Of course, the proof of our investigation was that we are still using beryllium-copper and intend to continue, with the knowledge that none of our people can be harmed."

Most fabricators of beryllium products are interested in the commercial alloys. Some few use a master alloy to introduce beryllium into an industrial alloy. Master alloys contain from 3 to 10 percent, and in some extreme cases, from 20 to 50 percent beryllium alloyed with copper, nickel, iron or aluminum. If there is any "problem" in connection with these master alloys it is sharply segregated to the only two sources of this material—and they report no "problem."

Commercial alloys contain from 2.25 to 0.1 percent beryllium alloyed with copper, nickel, aluminum or stainless steel. It can be flatly stated that these small percentages are harmless.

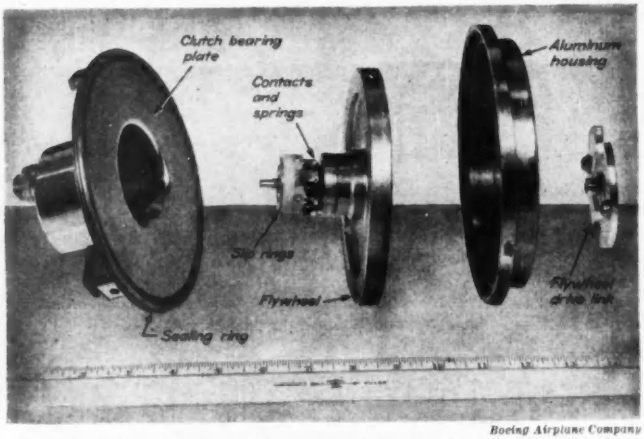
All evidence points to these general conclusions:

1. The presence of fluorine is necessary to cause dermatitis.

2. An acid radical in connection with beryllium is necessary to cause either of the two forms of pneumontitis.

3. Commercial alloys of beryllium are as safe to handle as any other commercial alloys. Dust or fumes from them should not be breathed.

4. While beryllium is not the killer that has been pictured, intelligent industrial practice, fortified by medical information, is always the price of life and health in all industry.



Boeing Airplane Company

ANTI-SKID BRAKING DEVICE for airplanes fits into landing gear wheel hub. Electrical and hydraulic connections are made at fittings on housing at left.

Automatic Braking Device Prevents Wheel Skidding

A BRAKE ATTACHMENT that automatically prevents skidding and is capable of substantially reducing airplane stopping distances has been developed by the Boeing Airplane Company of Seattle, Washington. Boeing has licensed Hydro-Aire, Incorporated, of Burbank, California, to manufacture and sell the new device commercially.

The new attachment, weighing 75 lb for the average airliner, is expected also to lengthen the life of airplane tires, which can be ruined by four or five seconds of locked-wheel skidding.

The system works like this: Once the airplane's wheels are on the ground, the pilot applies his brakes in the usual manner. Normal braking action results until a fraction of a second before the point is reached where a skid would normally set it on either or both sets of tandem wheels. At that point, the deceleration of the wheels on the runway causes a supplemental valve in the hydraulic system to open and reduce the braking power just enough to retain maximum braking action without skid.

Should either set of wheels decrease in speed again to a point where a skid becomes imminent, the valve regulating it reopens and repeats the action as often as necessary, always giving maximum braking power without skidding, until the airplane stops. In a typical dry-runway landing, four complete "on-and-off" brake cyclings were recorded in 3.2 sec. with no locking of wheels.

The control device consists of a rotary inertia mechanism and a system incorporating a flywheel, electrical contacts and slippage clutch, all hermetically sealed in an aluminum housing. The axis of the flywheel shaft is centered on the shaft axis of the landing wheel. The flywheel shaft is coupled to the landing wheel and turns integrally with it. Screwed to the flywheel shaft is a bushing of insulating material and on this bushing are two or four electrical contact points, each of these two contacts being half of a pair. The bushing also has two slip-rings for carrying electrical current and an arm that rests between the ends of a centering spring. Center of the spring connects with a bronze bushing that is free to rotate about the flywheel shaft within the limits of the centering spring—25 deg either side of center.

The bronze bushing also carries the other two electrical contacts, which are grounded electrically to the flywheel shaft by a wiping spring. The slippage clutch connects the bushing and the flywheel with a gear on the bushing and eight spring-loaded ball bearings on the flywheel. These bearings are "pushed" at the teeth of the gear at angle 24 deg from the radius so that the flywheel speeds up rapidly when the landing wheel turns and keeps on running when the landing wheel slows down.

As the rotational force of the landing wheel is transmitted into the flywheel, the clutch slips for a second, but, as soon as the flywheel is rotating as fast as the landing wheel, slip-

page stops. The skid detector thus is centered the same as when it is at rest, with both pairs of electrical contact points separated. Since no current is flowing, the solenoid valve in the hydraulic line is not energized. When the pilot applies his brakes, the hydraulic fluid flows into the brake cylinder and pushes the shoes against the brake drum. Should the tire begin to skid, the rotational speed of the landing wheel decreases rapidly but the flywheel keeps on turning, transmitting back through the clutch some of the rotational energy it has received from the landing wheel and closing one pair of the electrical contacts. This action energizes the solenoid valve, which shuts off the hydraulic brake pressure, allowing the fluid in the brake cylinder to flow back into the reservoir.

As the landing wheel quickly regains speed, the first pair of contacts is opened and the second closed, de-energizing the solenoid valve, closing the "bleed" to the reservoir and allowing the brake pressure from the pilot to flow into the brake cylinder and apply the brake "full on" again.

In the case of icy or slick runways where a wheel may skid for a longer time or lock and a "brake off" signal persists beyond four-tenths of a second, the function of the second pair of contacts is automatically changed so that, when the skid stops, the "brake off" condition is maintained until the landing wheel regains rotational speed and transmits this speed into the flywheel.

Brakes go "full on" and "full off" two or three times a second. The device is equipped with a "fail-safe" provision so that, if the electrical power supply should fail, the pilot can still have full use of his brakes, although without the anti-skid protection.

Homopolar Generator Produces 21,000 Amperes

A PRACTICAL HOMOPOLAR GENERATOR that will produce large amounts of current at low voltage without ripple has been developed by the Electric Products Company of Cleveland. Based on designs and patents of James Caputo, a Youngstown electrical consultant and engineer, the unit is not built along the accepted lines of an electrical generator.

The 13-ft high, 30-ton machine, about 5 ft in circumference, is powered by a 600-hp motor located on top. It produces 21,000 amps at 18.7 v at 1,200 rpm, and costs about two dollars per hour to operate. By slightly lengthening the collector bars it can be made to deliver 100,000 amperes.

It was built vertical because such a design makes for better balance in the machine, provides for ready accessibility to all parts and conserves floor space.

Cost of the machine under ordinary circumstances would be about $50,000, but since Robert Berry, president of Electric Products, has more than a passing interest in nuclear research, the Carnegie Institute of Technology gets the machine at a bargain rate for its Nuclear Research Center at Saxonburg, near Pittsburgh. There the generator will be used to excite a 1,100-ton magnet.

To overcome heating problems, the 160 brushes on the machine are water cooled. Water coming through the center shaft is also used to cool the solid beryllium-copper collector ring.

The overall mechanical and electrical design is such as to reduce the effects of magnetic flux leakage to a minimum and to provide a balanced flux. The current is picked up from the collector rings and carried through the machine so as to equalize the flow of current through the collector and the magnetic flux across the air gaps.

Thus the flux passes from the field pole face through the collector into the shaft, through the shaft and into the end bell; from the end bell to the stator frame and back to the field pole face.

The entire rotating system is carried on two spherical roller thrust bearings, one just below the motor mount on top of the machine; the other under a magnetic disk at the bottom.

The field flux, returning from the shaft to the end bell, is put to work by being diverted through the rotating disk below the end bell. A magnetic lifting force is thus set up to ease the load on the lower bearing when the machine is running.

To minimize the possibility of the bottom bearings becoming miniature generators themselves when the machine is in operation, the bearing housing is made of non-magnetic aluminum alloy to keep field flux from straying into the bearings. Supplementary air gaps are built in to collect such stray fields.

Electric Products started construction of the present machine last September. Already on the drawing boards are plans for a generator with a capacity of one million amperes at 50 volts.

Battelle Institute Adds To Electrical Facilities

WITH THE COMPLETION of a new laboratory area and the enlargement of its electrical engineering staff, Battelle Institute, Columbus, Ohio, has embarked upon an expanded program of research in electrical engineering. The step, according to Battelle Director Clyde Williams, is aimed at providing adequate research facilities for companies not equipped to conduct research on complex electrical engineering problems.

Battelle studies in electrical engineering will include circuits, electrical machines, instruments, servomechanisms, analogue computors, ultrasonics, X-rays, electromagnetic fields, high-frequency equipment, materials testing, development of electrical conducting and magnetic materials, the design of systems involving nonlinear magnetic and semiconductor circuit components and illumination. Research in these and related subjects will be available to industry on a cost basis. Dr. Robert C. McMaster is in overall charge of this varied program of research.

The Institute's broad program of research in industrial physics is under the general direction of Dr. H. W. Russell, assistant director and chief

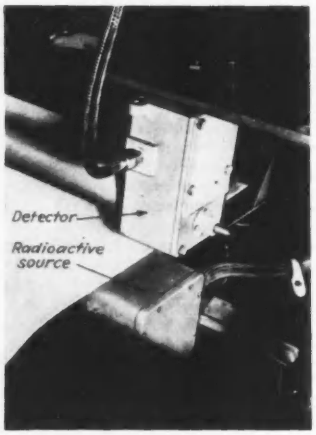
physicist. Heads of other physics research sections include Dr. R. W. Dayton, L. R. Jackson, Dr. H. R. Nelson, and Dr. F. C. Todd.

Some of the Institute's past projects in electrical engineering have included developments in electrical instrumentation for the rapid measurement of stress, strain, temperature and other variables; the development of electronically controlled, high-current power supplies for the rapid heating of materials during testing; and the development of magnetic materials for specialized applications in magnetic recording. High-efficiency mechanical rectifiers; electrical heaters for airplane propeller blades; instruments and techniques for arc and resistance welding; and designs for high-frequency sources have been other products of Battelle laboratories.

Thickness Gage Uses Strontium Isotopes

A BETA GAGE, which is the prototype of a series of measuring and control instruments to incorporate radioactive isotopes, represents one of the first major industrial uses of Oak Ridge-produced isotopes.

The essential components of the gage are a source of beta radiation from Strontium-90 and a radiation detector. The sheet material to be measured is interposed between the source and the detector and a part of the radiation is absorbed by the sheet material in proportion to its weight per unit area. This weight or thickness is read on a calibrated recorder connected to the detector. The recorder scale can be calibrated in terms of a plus or minus deviation from specifications or as an absolute thickness or weight reading.



BETA GAGE uses Strontium-90 isotopes to determine thickness of box board. Readings are recorded on strip chart.

For all practical purposes, the chemical composition of the sheet being measured does not affect the calibration of the instrument. The gage is comparable to a chemical balance in that it will provide the same information as is obtained by weighing on a balance a known area of the sheet material in question. Moisture, clay, chemicals, etc., affect results only in proportion to their weight.

One of the advantages of these gages is that no physical contact is made with the material being measured. Therefore, no marking of delicate or easily marred surfaces is possible as is the case with mechanical and other contacting gages.

A few typical uses of the gage are measuring cellophane and other thin plastic films, plastic and rubber sheets up to $\frac{3}{16}$ in. thick, paper ranging from heavy board to extremely thin condenser paper less than 0.0002 in. thick, sheet metal including steel and brass up to 0.040 in. thick, thin aluminum foil, textile yarn and roving and coated textiles such as artificial leather.

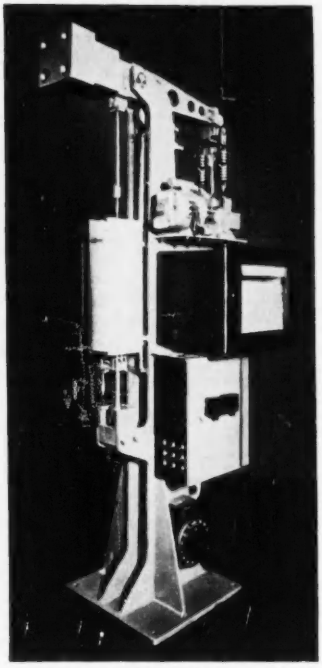
The Model SM-2 Tracerlab Beta Gage uses a Brown Electronik Recorder and the gage standardizes itself completely automatically every thirty minutes. The inherent accuracy of the gage is ± 0.05 percent of sample thickness or ± 0.03 mg/cm^2, whichever is larger. The amount of drift occurring between standardization periods is within the limits of inherent accuracy of the gage. Batteries that require renewal no more often than three a year are used as power supply to obviate the need for a closely regulated a-c power supply. Maximum sensitive length of the gage is 15 in., while its minimum length is $\frac{1}{4}$ inch.

Tracerlab, Incorporated, of Boston, Massachusetts, are the manufacturers.

Relaxation Tester Plots High-Temperature Creepage

RELAXATION TESTS at temperatures up to 1,800 F can be carried out automatically, including a record of the rate of decline of load, with a new 4,000-lb machine announced by The Baldwin Locomotive Works.

Relaxation occurs when a material is stretched to, and held at a given elongation, as in bolts, particularly at elevated temperatures. Creep then tends to elongate the bar and release the load. Elastic shortening balances this effect and total strain remains constant.



RELAXATION MACHINE automatically compensates for high temperature creepage. Recorder plots stress-time curve.

The machine automatically relaxes tensional loads from as high as 40,000 psi, permitting strain increments of only 2×10^{-6} in. per in. of the 6-in. gage length of a standard 0.356-in. diameter specimen. Increases in length are detected by a highly sensitive extensometer with electric contacts that close a 6-v relay circuit and thus operate a $\frac{1}{4}$-hp servo-motor to reduce the load enough to open the contacts again and to maintain a substantially constant strain.

Load is reduced through a worm and gear box, iso-elastic springs by which the load is measured, and a lever arm with a mechanical advantage of 8 to 1. Accuracy is held to approximately 1 percent of load or 0.25 percent of capacity.

The recorder produces a curve of stress vs time on a flat chart slightly less than 10-in. wide. The stress axis is driven indirectly from the spring loading device.

Washington Notes

Science Foundation Bill Will Put Government In Business of Basic Research

AFTER FOUR YEARS OF TRYING, Congress is finally going to set up a National Science Foundation to promote research in universities and laboratories. And indications are that by the time this issue appears, Congressional action will have made the Foundation a reality.

The Priest bill approved by the House Interstate Commerce Committee meets the objections President Truman had against legislation he vetoed two years ago. And Rep. Priest of Tennessee is pretty sure he can get the green light to put the law through the House before summer adjournment. The Senate already has voted a similar bill.

The proposal puts the federal government into the business of developing such sciences as mathematical, engineering, physical, medical and biological. Cost will be roughly $15-million in the first year, stepping up to $25-million a year when the program is in full sway.

In brief, the Science Foundation will:

(1) Maintain a register of scientific and technical personnel; provide a clearing house for information covering scientific and technical personnel.

(2) Award scholarships and graduate fellowships to students for basic research — the awards will total roughly $2.5-million a year.

(3) Contract with universities and laboratories for scientific research in the various fields such as engineering and physics—the contract authority is budgeted at $12.5-million for the first year.

The Foundation will consist of four divisions to direct research in medicine, engineering, mathematical and physical sciences, biological sciences and scientific personnel and education.

The major difficulties the program has had in the four years it has been before Congress were over the administrative set-up, and the question of patent rights.

Truman vetoed the only measure Congress sent him because the proposed governing board of the Foundation would have been practically autonomous. The Priest bill provides that major executive functions will be in the hands of a $15,000-a-year director responsible to the president.

The proposed National Science Board would be made up of 24 members appointed by the president and confirmed by the Senate for six-year terms. Members normally would be selected from the various fields or basic science, including the social sciences.

The board itself would meet but once a year. However, an executive committee would, at the request of the director, meet more often to advise on policy.

As to patents, the Priest bill puts the developments of the Foundation under the regular patent laws. The exact language in Section 12 of the Priest bill is: "Nothing in this act shall be construed to authorize the Foundation to enter into any contractual or other agreement inconsistent with any provision of law affecting the issuance or use of patents . . ."

Recipients of scholarships must be American citizens but would be permitted to use the money at non-profit American or foreign institutions. Recipients would have to swear they do not belong to or support any organization that advocates overthrow of the government by force or violence.

Though the Foundation has the right to acquire property and to publish periodicals about its work, it must contract to others all research work.

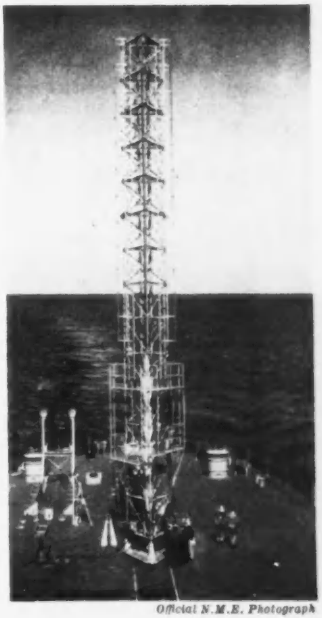
COMMENT below by Dr. Karl T. Compton, Chairman, Research and Development Board, expresses the significance and need for a permanent organization to promote basic research.

"The National Science Foundation Bill is designed to achieve two major purposes vitally necessary for the future progress of science in this country—the increased financial support of basic research, and the increased support of education for scientists and engineers. In both respects the amount of private resources which are available needs to be supplemented on a national basis. This is because of the limitations of private funds and the increasing cost of scientific research. The Foundation would be directed by the ablest scientists obtainable, with an aim not of domination of the nation's research, but of supplementing the research effort that exists already, filling gaps, providing emphasis in important fields, and indeed providing a means for ascertaining just what the current emphasis is. The tremendous concentration upon applied research over the last ten years has practically exhausted the stock-pile of fundamental knowledge in many fields.

"I believe that by wise use of public funds, through the media of grants to, or of contracts with, existing research laboratories, and of science fellowships, the National Science Foundation will provide a steady increase in the quality and scope of basic scientific knowledge and of research personnel, upon which, after all, applied research, and the myriad applications in peace-time industry and national defense must rest."

Sounding Rocket Reaches Height of 65 Miles

A Navy Aerobee sounding rocket was fired recently from the deck of the U.S.S. Norton Sound. The rocket, designed primarily for high altitude research, attained a height of more than 65 miles above the ocean. Data obtained by instruments in the nose



Official N.M.E. Photograph

of the rocket reveal that cosmic ray intensity above the atmosphere at the geomagnetic equator is twice as great as had been estimated. By observing the powerful cosmic ray particles and studying the changes they undergo in flight, scientists hope to obtain a new understanding of nuclear forces.

Special Instrumentation Needed for Atomic Plants

Special instruments that can be used in areas of intense radiation and high temperatures must be developed before atomic power plants can be widely used.

Instruments are needed for control and safety of plant operation, for observing the condition and behavior of the plant and for monitoring radiation leakage to assure protection of operating personnel. They must have extreme reliability, remote maintenance, resistance to neutron and gamma radiation, absolute leak tightness and long service.

Maintenance by remote control is necessary, since it is not possible to perform direct inspection and maintenance work on the detecting devices within the radioactive zone. When a failure occurs, it may be necessary to remove and replace the instrument by remotely operated equipment.

Heat Treatment of Crystals Prevents Deterioration

The U. S. Signal Corps has come up with a significant discovery in the processing of quartz crystals—heat treatment and cooling that prevents deterioration. The development will mean substantial economies in both governmental and industrial communications equipment.

U. S. Army Photograph

QUARTZ CRYSTALS lose tendency to deteriorate after being heated in oven for a period of two to three hours.

The new process, discovered by scientists of the Frequency Control Branch of the Signal Corps Engineering Laboratories at Fort Monmouth, New Jersey, virtually does away with the aging characteristics of quartz crystals. Treatment consists of superheating blank crystals to approximately 900 F over a period of two to three hours and then cooling them under exactly controlled conductions for 24 hours.

The discovery promises proportionate savings in the future for all types of modern communication services, including television, radio broadcasting, point-to-point radio, and in hundreds of types of military equipment. Smaller, lighter and better walkie-talkie, aircraft, tank and combat radios will also be possible.

"Silent" Engine-Generator Developed by Military

Chirping of crickets and the whisper of wind in the grass are enough to drown out the sound of a new 1½-kw engine-generator set produced by the Engineer Research and Development Laboratories, Fort Belvoir, Virginia. Labyrinthing and glass wool lining of a special aluminum silencer box weighing 93 lb does the trick. On a quiet summer evening, the set has an audible range of 325 ft from the rear (exhaust) side, and only 200 ft from the front.

Sound technicians conducted audibility tests of the machine at night on a flat meadow. A relatively low ambient noise level (35 decibels) was recorded at the time. This low recording resulted largely from competition by crickets and a gentle breeze in the grass. The technicians observed that, under quieter conditions, it might have been possible to record the noise of the generator set 50 or 75 ft farther from the machine.

Subsequent tests were conducted in a "dead sound" room where the noise level and sound reflections were as near zero as is possible to attain. These tests revealed that an overall noise reduction of 25 decibels was obtained. A reduction of 30 decibels in certain critical frequencies also was recorded.

The circuitous air intake and exhaust ducts of the silencer box are lined with 1 in. of glass wool (fiberglas) cemented to the walls with dumdum. In the engine housing, 2 in. of the blanket are cemented to the interior walls. A "tuned" second muffler for the engine exhaust reduces the noise of the set still further.

The engine-generator is designed to power a lighting set for command posts, small field hospitals and other installations where the power demand does not exceed the capacity of the equipment.

Needed—Fabricators Of Magnesium Sheet

The military, worried about a continuing supply of magnesium sheet for planes, has broadcast an appeal to industry for help in the situation. What Wright Field procurement people want metal fabricating plants to do is study the problems of rolling magnesium sheet and go into the business.

The idea here is twofold—to increase the potential supply of magnesium sheet, and to engender enough competition so as to reduce the price of the material.

There is now only one major magnesium sheet producer, The Dow Chemical Company, but they are finding it hard to keep up with the demand. According to reports, the military could use another 100,000 pounds of sheet a month.

So far, the recruiting drive for more producers of magnesium sheet has not paid off in anything more than "dribs and drabs." Although the military thinks the supply situation for the light-weight sheet will remain tight, but not critical, for another six or seven months, the future outlook for the supply is not promising.

The military itself calls the future turn here. Officials admit that the material is being used more and more in planes, both bombers and fighters. And, there is the expectation that private industry will find an increasing number of uses for magnesium sheet.

Anyone interested in trying his hand at rolling magnesium sheet can contact the Air Materiel Command, Wright-Patterson Air Base, Dayton, Ohio, for further information.

Broad Research Program Covering Bolt and Rivet Constructions Under Way

A PROGRESS REPORT covering seven research projects on riveted and bolted steel connections will be released shortly by the Research Council on Riveted and Bolted Structural Joints.

Some of the projects have already advanced to a stage where definite conclusions may be drawn. For example, reversal of load is reported to have little effect on joints held by the clamping pressure of high-strength bolts, and field tests on railroad bridges (as well as laboratory investigations) indicate that bolts stay tight without locking devices.

A second project concerned with the effect of bearing pressure on static and fatigue strength of riveted joints has also resulted in specific information. Pilot tests conducted at the University of Illinois on joints with hot driven rivets have indicated what some of the important variables are, and that certain statements can, at least tentatively, be made:

1. "High bearing pressure" is only another way of saying "thin connected material" (thin as related to the diameter of the rivet used); under working loads there may or may not be any actual bearing.

2. A rivet of short grip, driven through a number of plies of thin material, does not have the clamping force of a rivet of long grip, driven through the same number of plies of thicker material.

3. A rivet of short grip will, as a practical commercial average, fill its hole more fully than one of long grip.

4. Initial slip, which represents the overcoming of friction and brings actual bearing into existence as its consequence, may therefore start sooner with rivets of short grip (thin material) than with rivets of long grip (thick material); but should proceed over less distance before bringing up in bearing.

5. Slip is of less consequence in static than in fatigue loading.

6. In static loading, after initial slip has been arrested by bearing, three conditions are to be distinguished:

(a) If the critical plate is stressed in tension, and there is an insufficient distance from the rivet to the end of the piece, failure can occur through bulging out and ultimate bursting of the plate, beyond the rivet and in line with the load.

(b) If the critical plate is stressed in tension, and there is sufficient "end distance," then under ordinary relationships, failure will not occur by crushing of material at the surface in bearing, since this will be preceded by the failure of the plate on a transverse line through the hole or holes (failure in plate tension).

(c) If the critical plate is stressed in compression, then after initial slip produces actual bearing it is quite possible for thin material to fail by flow of the metal at the bearing surface. Safe limits and bearing allowances in tension and in compression remain to be investigated.

7. In fatigue testing, the rapid intermittent or opposed loading usually produces a rapid increase of heat soon after initial slip occurs. Therefore, high bearing stress may be much more destructive in fatigue than in static testing; not because of high bearing stress, but because of the short grips associated with thin material.

ASA Revises Standards For Circuit Breakers

NEW TABLES OF PREFERRED RATINGS for power circuit breakers have just been approved by the American Standards Association. They are the American Standard Preferred Schedules for Power Circuit Breakers, C37.6-1949, and are a revision of similar schedules issued in 1945.

This standard, developed by a committee of manufacturers, users and engineers especially interested in power switchgear under the procedure of the American Standards Association, meets all the usual needs of circuit breaker users and at the same time gives both manufacturers and users the benefits of standardization.

The schedules are presented in four tables of ratings covering circuit breakers of the following types: indoor oil, indoor oilless, outdoor oil and outdoor oilless, and low oil content. In this 1949 revision, the number of individual ratings has been reduced materially in each classification, resulting in a net over-all reduction of 43 ratings, from 121 in the 1945 Schedules to 78 in the 1949 edition. A revision of the "rated voltage" kv values to conform to the latest recommendations of the Edison Electric Institute—National Electrical Manufacturers Association Joint Committee on Preferred Voltage Ratings for A-C Systems and Equipment, and the addition of a column of "maximum design" voltage ratings for the information of the application engineer has also been accomplished. Thermal "short time" ampere ratings have been changed from five to four seconds and a "time in cycles" column has been added.

Industry Conference Edits Packing Standards

FOLLOWING PARTICIPATION in a Joint Industry Conference on Hydraulic Packings and Seals, which has meant several sessions in Detroit, the E. F. Houghton & Company of Philadelphia, has prepared a booklet listing standards for leather and synthetic rubber packings.

The purpose of the meetings was to emphasize upon packing suppliers the difficulties resulting from a lack of standardization and complete information as to proper application.

A system of coding and marking hydraulic equipment was proposed at the Conference and has been unofficially approved, subject to further study and action at the Conference's next meeting in September.

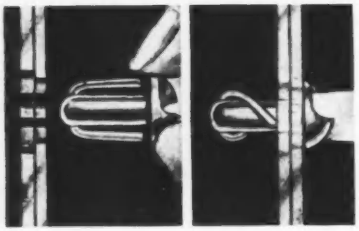
The Conference sought the combined thinking of packing and seal manufacturers in establishing standard engineering information that would guide users in selecting the correct type of packing for each application.

Those standards now being set up by Houghton as a manufacturer of packings serve to simplify the selection of packings by reducing the number of sizes and thereby cutting inventories. Interchangeability and easy identification are facilitated by establishment of dash numbers.

Army-Navy standards set up during the war represented the first effort toward such standardization, but in the opinion of the trade today, do not go far enough nor cover enough types of packings. For example, the AN-6225 standards included eighty sizes, which by J.I.C. action have already been reduced to forty-nine. Increment increases in the "ID sizes" table have been agreed upon by the Conference and will be generally adopted.

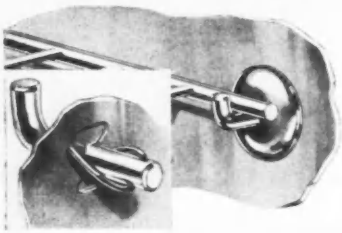
The 32-page booklet just released by E F. Houghton & Company lists standards based on the discussion at the J.I.C. meetings. The Mechanical Packing Division of the American Leather Belting Association and a number of the leading rubber packing suppliers have agreed to follow both the new standards and the marking codes.

Have you a similar use for this 1-piece fastener?



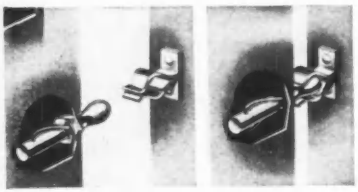
It's a Blind Rivet

. . . Or a removable fastener. It locks and unlocks with a 90° clockwise rotation. No mating parts such as nuts or receptacles are required.



It's a Shelf Support

. . . For ranges or refrigerators. Leading appliance makers have achieved substantial installation savings through its use.



It's a Cabinet Door Strike

. . . Simple to install, eliminates welding and cuts assembly cost. Any head can be designed without affecting fastening principle.

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High Temperature Characteristics of Heat Resistant Alloys

NORMAN S. MOTT
Chief Chemist & Metallurgist,
The Cooper Alloy Foundry Company

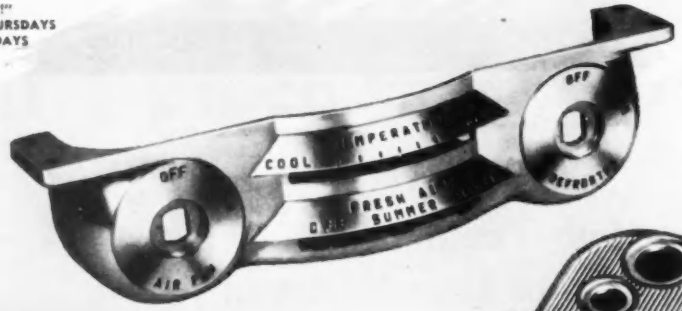
Heat Corrosion Code for use with Section 1	Carburization Resistance Code for use with Section 2	General Code for use with Section 3, 4, 5
E = Preferred < .05 ipy* G = Satisfactory 0.05–0.1 ipy* P = Excessive 0.1–1.0 ipy* N = Highly Excessive > 1.0 ipy* * Penetration in inches per year	E = Negligible Carburization G = Light Carburization F = Mild Carburization P = Heavy Carburization N = Very Heavy Carburization	E = Excellent G = Good F = Fair P = Poor N = Not usable

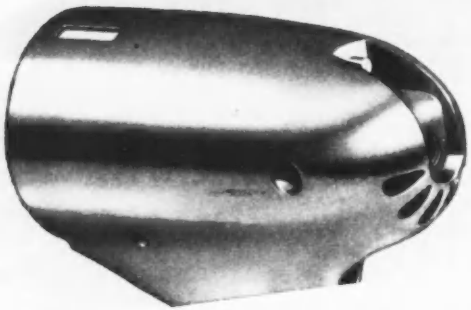
Alloy Designation	Alloy Type		28 Cr	18–8	25–12	25–20	35–15	60–12
	Corresponding Alloy Casting Institute Designations		HC	HF	HH	HK	HT	HW
SECTION 1 High Temperature Corrosion Resistance	Air Oxidation Resistance	@ 1,600 F	E	E	E	E	E	E
		1,800 F	E	P	E	E	E	E
		2,000 F	G	P	E	E	G	E
		2,200 F	N	N	G	G	P	G
	Oxidizing Sulfur Bearing Flue Gas Resistance	@ 1,800 F	E	P	E	E	E	E
		2,000 F	G	P	E	E	G	E
	Reducing Sulfur Bearing Flue Gas Resistance	@ 1,800 F	E	P	E	E	G	P
		2,000 F	G	N	E	E	P	P
SECTION 2 Resistance to Carburization	Pack Carburizing		P	—	F	F-G	G	E
	Gas Carburizing (< 15 percent CH_4)		E	—	E	E	E	E
	Bright Annealing or Hardening		E	—	E	E	E	E
	Carburization in Natural Gas		G	—	P	F	F	G
SECTION 3 High Temperature Properties	Hot Strength or Creep Resistance		P	G	G	G	G	E
	Hot Ductility		E	F-G	F-G	P-F	F-G	G
	Hot Impact Resistance		E	G	F	F	F	P
	Thermal Deformation Resistance		E	P	P	F	G	E
	Thermal Fatigue Resistance		P	F	F	F-G	G	E
	Resistance to Effect of Cyclic Heating		P	F	F	G	G	E
SECTION 4 Corrosion Resistance in Molten Heat Treating Salts	Drawing and Tempering Salts		—	—	F	G	G	E
	Neutral Salts		P	—	F	G	P	P
	Cyaniding Salts		—	—	F	G	G	E
	High Speed Salts		—	—	F	G	F	N
SECTION 5 Molten Metal Corrosion Resistance	Lead		—	—	G	—	G	E
	Tin		—	G	—	—	G	G
	Babbitt		—	—	—	—	P	P
	Aluminum		N	N	N	N	N	N
	Magnesium		G	N	N	N	N	N

GENERAL GUIDE FOR USAGE

28 Cr	For coarse furnace parts
18–8	For heat uses under 1,600 F
25–12	For economical high temperature structural applications
25–20	Best all around alloy for high temperature service
35–15	For carburization and cyclic heating services
60–12	Premium alloy for carburization and cyclic heating services

TUNE IN "SUSPENSE!"
CBS RADIO NETWORK THURSDAYS
CBS TELEVISION TUESDAYS





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DIE CASTINGS

● Increased production facilities for die castings made possible through the famous Auto-Lite "controlled metals" processes are now available. The opening of the great new Lockland plant of Auto-Lite, combined with the enlarged facilities at Woodstock, Illinois, greatly increases Auto-Lite's ability to furnish high quality die castings.

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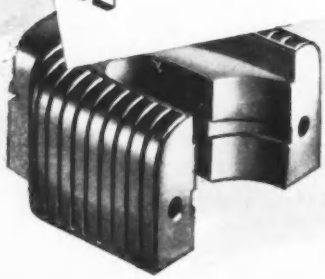
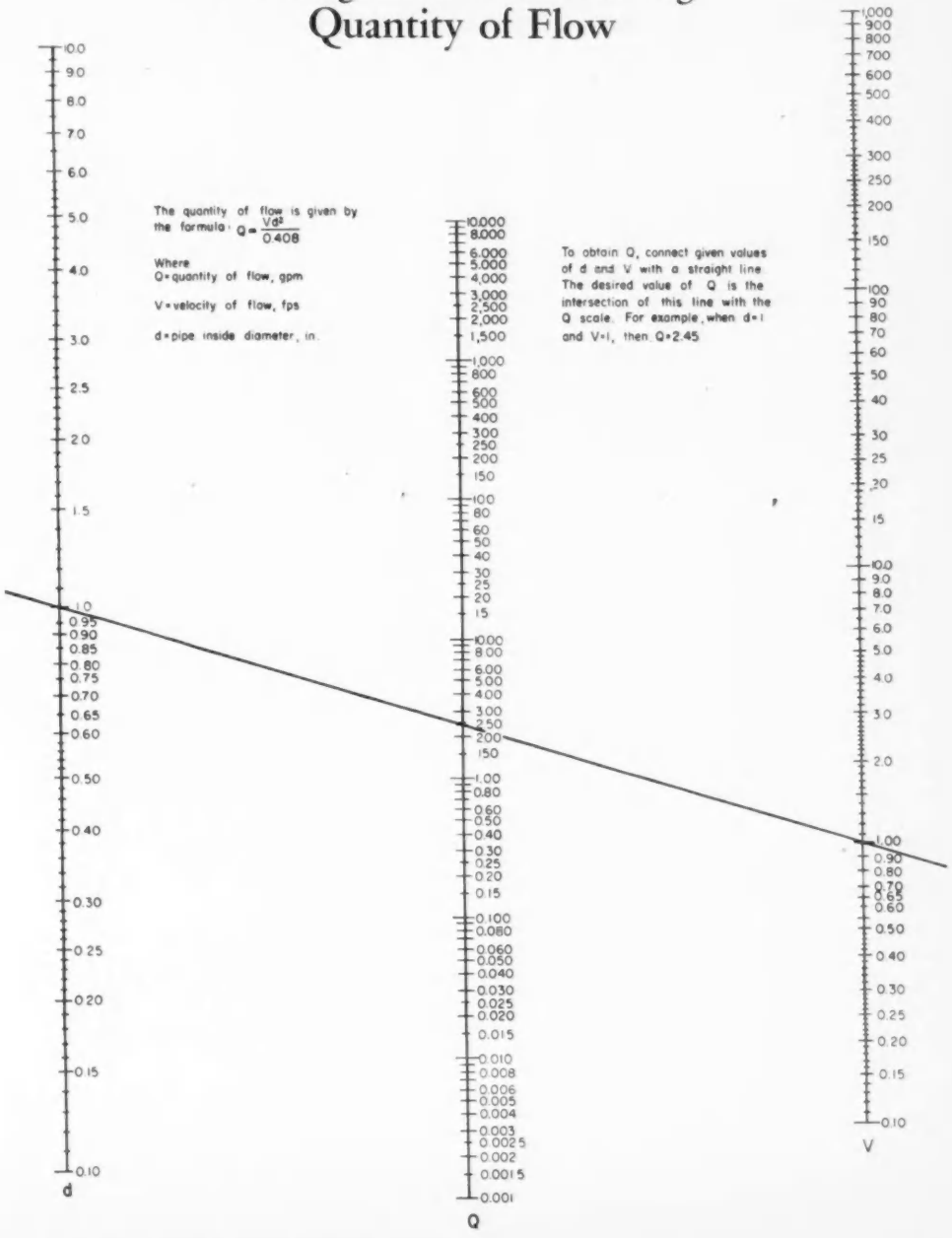
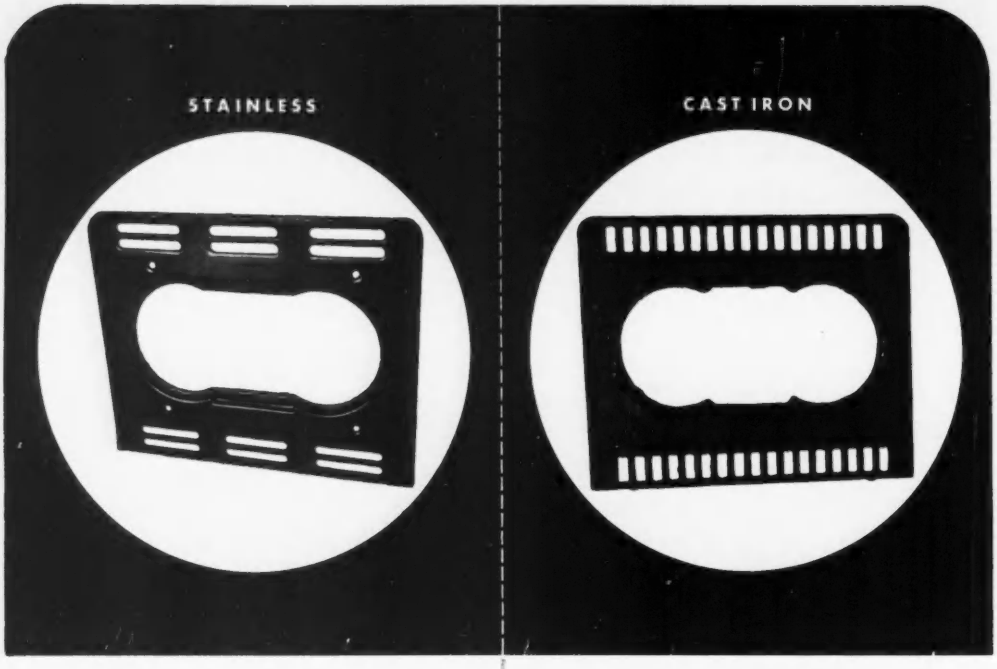


Inquiries invited

Catalog will be sent on request.
Write on your company letterhead.

Nomogram for Calculating Quantity of Flow


The quantity of flow is given by the formula: $Q = \frac{Vd^2}{0.408}$
Where
Q = quantity of flow, gpm
V = velocity of flow, fps
d = pipe inside diameter, in.
To obtain Q, connect given values of d and V with a straight line. The desired value of Q is the intersection of this line with the Q scale. For example, when d=1 and V=1, then Q=2.45
d
Q
V



Where Stainless Costs Less Than Cast Iron!

COST-CASE OF A STOVE TOP
(From Actual Records)

3/16" IRON CASTING		.050" ARMCO 17 STAINLESS STEEL	
Weight of Casting	10 lbs.	Weight of Blank	4.1 lbs.
Cost of Casting	$ .90	Cost of Blank	$ 1.39
Pre-Enamel Finish	.20	Stamping	.04
Enameling Cost	.60	Blackening	.15
	$ 1.70		$ 1.58
5% Rejections	.08	1% Rejections	.02
	$ 1.78		$ 1.60

This case of a stainless steel stove top that costs *18 cents less* than a cast iron top is another example of the savings that more and more manufacturers are making with Armco Stainless Steels.

And besides the savings shown in this cost breakdown, the manufacturer salvages the stamped-out stainless center section for another important part of the range. Shipping costs on the stove are lower too, because the finished stainless top weighs 7 pounds less than the iron casting.

So the manufacturer cashes in on a substantial cut in production costs, and the housewife gets a better kitchen range. The stainless top is more corrosion resistant, lighter, and won't break.

This is one example where the handsome appearance of Armco Stainless has nothing to do with its selection for the stove top. The part is blackened by the Armco Blackening Process to maintain color uniformity at high temperatures.

Using Armco Stainless Steels to *cut first-cost* and improve products or equipment is nothing new; it may be possible in your business too. So why not take the first important step today by analyzing *your* finished product costs using this rustless steel. Armco engineers will be glad to talk it over with you.

Just address Armco Steel Corporation, 3579 Curtis Street, Middletown, Ohio.

ARMCO STEEL CORPORATION

Nomogram for Dielectric Heating

CARL P. NACHOD
Nachod & U. S. Signal Co., Inc.

WHEN HEATING non-metals dielectrically, the heat is generated evenly throughout the body of material. But, before the heating process is begun, voltage and frequency designations must be set on the heating generator. These factors are expressed in the equation:

$$W = \frac{1.41\, af\, E^2\, \epsilon}{10^{12}\, d} \quad \text{or} \quad E^2 = \frac{10^{12}\, Wd}{1.41\, af\epsilon}$$

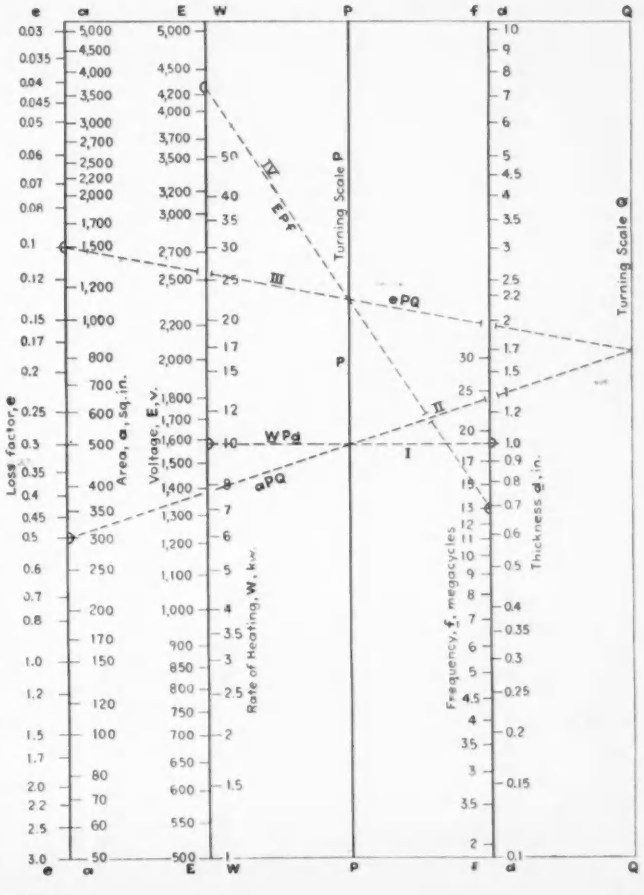
where

W = rate of heating, watts [kw on chart]
a = area of electrode, sq in.
d = thickness of material heated, in.
f = frequency, cps [megacycles, on chart]
E = voltage, rms
ϵ = loss factor of material

The following nomogram will facilitate the evaluation of the voltage and frequency variables. To find E from the nomogram draw the 4 computing secants in the numerical order shown and to the several scales which they cut For example, if $W = 10$ kw, $d = 1$ in., $a = 300$ sq in., $\epsilon = 0.1$ and $f = 13$ megacycles. To solve this problem for E as shown in the chart, first draw secant I with the given values of W and d. Then inscribe the second secant from 300 on the a scale through the point where secant I intersects P, and extend this line to the turning scale Q. The third secant follows through this point on Q to the given value of e on the extreme left hand scale. Now the fourth secant can be drawn from the value 13 on the f scale through the intersection of secant III and P. Extension of this final line will show that the value of E is 4,270 volts.

In cases when both f and E are variables, convenient values for both may be found by pivoting secant IV about the known point on P.

The loss factor, ϵ, used in the above example, is the product of the dielectric constant and the power factor. And since this loss factor varies with different materials, it is possible to heat a mixture selectively. One outstanding application of this process is edge gluing of wood panels. The glue has the higher loss factor, and so receives a greater quantity of heat than the wood. In the food industry the same principle is utilized to kill bacteria in malt and insects in grain.



the trend is to N-A-X HIGH-TENSILE STEEL for

BUMPERS • GRILLES • HOODS
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N-A-X HIGH-TENSILE MEETS ALL REQUIREMENTS OF S.A.E. 950

Specify N-A-X HIGH-TENSILE STEEL

GREAT LAKES STEEL CORPORATION
N-A-X ALLOY DIVISION • DETROIT 18, MICHIGAN
Unit of National Steel Corporation

NEW MATERIALS AND PARTS

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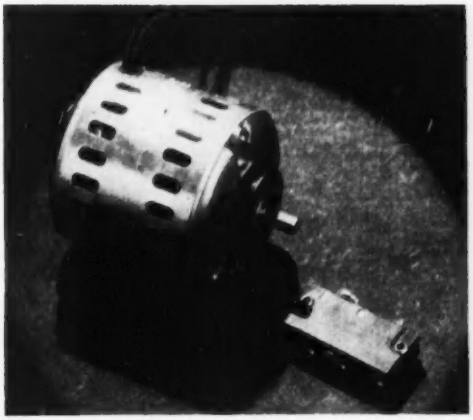


Constant Speed FHP Motor

General Electric Co., Schenectady 5, N. Y.

A new line of light-weight, constant-speed FHP motors designed for use in typewriters, accounting machines, and other business machines has open, ventilated, sleeve-bearing construction. The new Type KH motors are available in these ratings: 1/40 hp, 1,725/1,425 rpm, 115 v, 60/50 cycles; 1/40 hp, 1,425 rpm, 115 v, 25 cycles; 1/20 hp, 3,450/2,875 rpm, 115 v, 60/50 cycles. All are equipped with double-bonded resilient mounting rings, including latches, and three 12-inch leads. Fans cast integral with each end of the rotor provide good ventilation and permit the use of a minimum amount of copper and iron; this results in a motor of reduced weight—4 pounds.

Thermosetting Phenolic Plastics

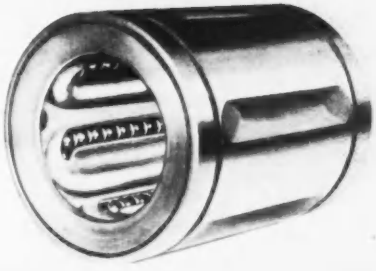
Rogers Corp., Manchester, Conn.

Two new phenolic materials can be easily poured or automatically preformed. They can be compression, transfer, or plunger molded to produce medium-high impact characteristics in the range of 0.65 ft lb per in. of notch, by the Izod impact strength test. The recommended molding pressure range is 4,000 to 6,000 psi. Compression strength is 25,000 psi, tensile strength is 5,500 psi, and flexural strength is 8,000 psi. These materials have a fast rate of cure and have a black, high gloss finish. The high strength characteristics combined with easy-molding properties make them useful for large components such as transformer housings, outlet boxes, industrial light sockets, coil forms and other such uses.

Linear Ball Bearing

Thomson Industries, Inc., Manhasset, N.Y.

Designed for 1½ in. guide rods, this new linear ball bearing has a greater load rating than the linear bushings previously available. It is useful for anti-friction support of linear motions where shaft rigidity and load capacity are of prime importance. Affording extremely low friction and a close fit to the guide rod, the bearing eliminates the binding and chatter which accompanies close fit plain sliding bushings. The precision alignment is maintained over long periods, since the free rolling ball bearing action eliminates wear. Since the rolling ball principle is not dependent on a grease film for free action, the bearing solves many lubrication problems usually associated with guide rods. The outside dia of the bearing is 2.375 in., and overall length is 3 inches.



Whiteprinting and Developing Machine

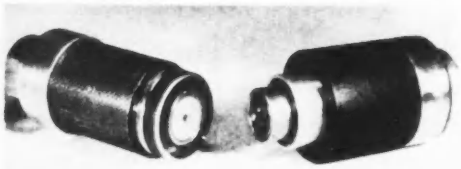
The C. F. Pease Co., 2631 W. Irving Park Rd., Chicago 18, Ill.

Model 60-G is a medium production dry direct process machine having a new light source which permits printing speeds up to a maximum of 18 ft. per min. This feature is outstanding because the printer and the developer are synchronized to the same mechanical speeds which eliminates any possibility of a "bottle neck" between printing and developing operations. A Constant Wattage Transformer is of special significance where power line variations may occur. It provides efficient tube performance even though power line variations may range from 200 to 250 volts. The life expectancy of the tube is increased by this special feature. Filling the ammonia reservoir tank has also been simplified by means of the New Type Ammonia Pump. Aqueous ammonia is pumped from the supply bottle, which is located within the cabinet with speed and ease. This feature eliminates the need of pouring aqueous ammonia from container into developer reservoir.

Hydraulic Coupler

B A Coupling Co., Inc., 1658 N. Brookfield St., South Bend 28, Ind.

New "breakaway" hydraulic coupling instantly checks the flow of oil under pressure, sealing both ends of the line. The coupling can be re-connected under maximum dynamic pressure. When disconnected under pressure there is not more than two drops of oil spillage. After a quick thumb-wipe the unit is ready to be re-coupled.



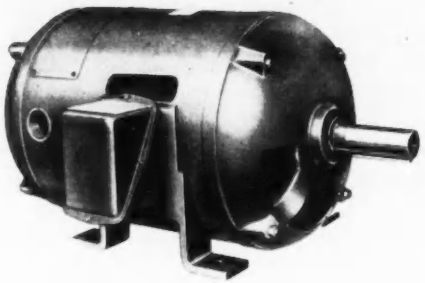
Filling safety requirements and protecting hose lines, breakaway occurs at 50 lb with 0 psi; 75 lb with 1,500 psi and 100 lb with 2,000 psi. Hose lines are further protected through free swivel action under all conditions up to 4,000 psi. Both halves can be connected to seal the circuit when not in use.

Flexible Chain Couplings

Borg-Warner Corp., 310 S. Michigan Ave., Chicago, Ill.

This new line of silent chain flexible couplings is designated series DSC. The unit consists of two sprockets wrapped with a center guide Morse Silent Chain. Installation is extremely simple. After removing one pin the chain may be unwrapped, or either of the sprockets may be pulled endwise out of mesh with the chain. These couplings combine a maximum of power transmission

capacity with minimum space requirements. Stock bores range from $\frac{1}{2}$ to $2\frac{7}{8}$ in. with capacities up to 119 hp at 2,000 rpm. Two covers are available—stamped steel for economy and plastic for maximum protection.



Wound-Rotor Motors

Crocker-Wheeler Electric Mfg. Co., Ampere, N. J.

The Form BW protected type wound-rotor a-c motor, built in NEMA frames 224 to 505, is available in ratings up to 100 hp. With larger frames these motors are furnished up to 2,000 hp. Standard units have drip-proof frames and end shields. In addition, units can be obtained with splash-proof and totally-enclosed non-ventilated construction. Other mechanical modifications available include NEMA floor, sidewall, ceiling, C face and D flange mountings. These motors are to be used

To save time on machine design ...specify piping from one complete line

That, of course, is the Crane line—the world's most comprehensive selection of valves, fittings, pipe and accessories. So why look elsewhere next time you specify piping equipment? You'll find whatever you need, right at your finger tips, in your Crane Catalog.

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For this "Save Condensation" Boiler System, for example... as for larger and more complex machinery... Crane is the **One Source of Supply** complete enough to simplify every piping procedure, from drafting room to your product assembly line.

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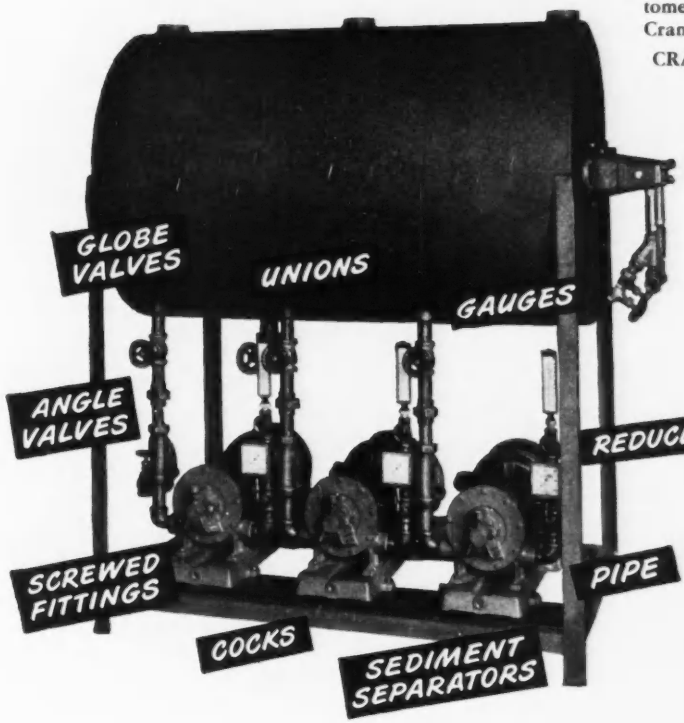
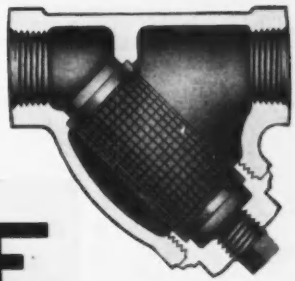


McKee "Save Condensation" Boiler System by Eclipse Fuel Engineering Co., Rockford, Ill.

FOR MAXIMUM PROTECTION *against damage from grit, dirt, scale and foreign matter in steam, water, air, oil and gas lines... Crane recommends vertical screen or Y-pattern sediment separators, in iron or steel. Extra large screening areas, with screen of mesh and materials best suited for service specified, assure free fluid flow and minimum pressure loss. Sizes: up to 12 in. Working pressures to 600-pounds steam. Flanged or screwed ends. See your Crane Catalog.*



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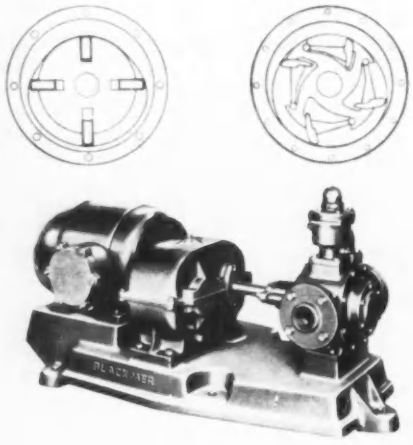
where smooth acceleration, high starting torque, low starting current, quick stopping and reversing, or variable speed are necessary. Normal useage will be with conveyors, presses, fans, compressors, etc. Special windings are available for crane or hoist service.



Rotary Pump

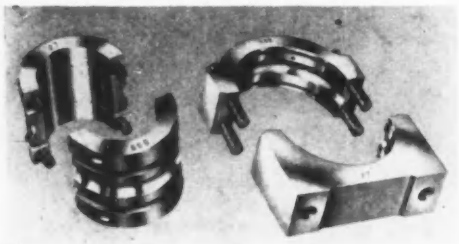
Blackmer Pump Co., Grand Rapids, Mich.

New sliding vane type rotary pump handles extremely viscous liquids up to 100,000 SSU. Also, gasoline and other volatile liquids can be pumped more efficiently and at high lifts. The vanes are made of a sound-deadening, non-metallic material which gives a quiet and wear-resistant operation. The self-adjusting vanes are actuated by push rods through the rotor and shaft, and are replaceable without disturbing piping or drive. Sliding vane type pumps are not recommended for use with liquids containing solids.

Pillow Blocks

Split Ballbearing Corp., Lebanon, N. H.

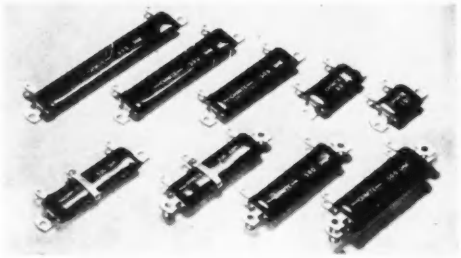
In this newly designed pillow block the housing and outer race are forged integral from bearing steel. Both the inner and outer races are split or fractured and repositioned by holding screws. This construction permits the assembly of the bearing in places where a solid race bearing cannot be installed. As a replacement bearing, it can be assembled without stripping the shaft or dismantling attached mechanism. It is exceptionally compact and has a high load capacity, due to the maximum complement of balls that can be assembled because of the split construction. Ideal as replacement bearing for reducing downtime, it can be included in original design where bearing replacements are anticipated. These bearings are now available for shafts $\frac{1}{16}$ to $3\frac{15}{16}$ in. in diameter.



Thin Resistors

Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.

Providing high wattage per unit of space, new, wire-wound, vitreous-enameled, thin-type resistor is 1 in. wide and $\frac{1}{4}$ in. thick. Lengths vary from $1\frac{1}{4}$ in. for the 30-watt size to 6 in. for the 75-watt size. Five wattage sizes are available, all in a wide range of resistance values. They are equipped with either a single-unit mounting bracket —which allows the resistor to be mounted close to the mounting surface—or with a stud bracket which provides for the stacking of two or more resistors. They are available as fixed units or adjustable lug units.



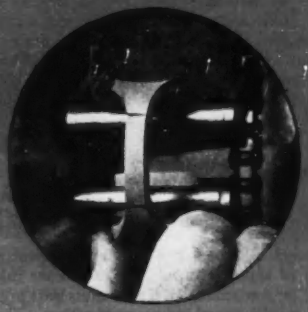
Totally Enclosed Motor

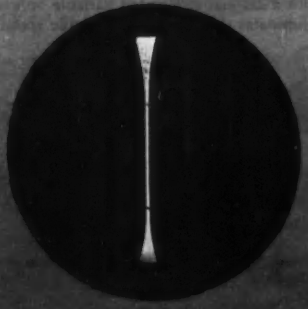
The Brown-Brockmeyer Co., Dayton 1, Ohio

Called the B-Line, this new series of motors is designed for operation in non-explosive atmospheres where metallic and abrasive dusts are prevalent. Cooling is improved by a newly designated fan which directs air directly over the stator lamination edges. Since the space between the laminations and the field ring are used for air cooling,

SILASTIC* 250

THE TOUGHEST, MOST STABLE SILICONE RUBBER EVER MADE





FROM 500° F. TO -130° F.

Over a temperature span of 630° F., Silastic 250 has:

GREATER TENSILE STRENGTH . . . PLUS GREATER TEAR RESISTANCE, GREATER ELONGATION, BETTER ELECTRICAL PROPERTIES THAN ANY OTHER RUBBER-LIKE MATERIAL

SILASTIC 250

WITH GREATLY IMPROVED MECHANICAL STRENGTH

- tensile strength times elongation is increased by a factor of 2 to 6
- tear resistance is increased by a factor of 3

IMPROVED DIELECTRIC PROPERTIES

- dielectric strength ..... 700-900 volts per mil
- dielectric constant
  - at 100 cycles per second 3.1
  - at 1,000,000 cycles per second 3.0
- power factor
  - at 100 cycles per second 0.2%
  - at 1,000,000 cycles per second 0.8%

PLUS LOWER COST

- specific gravity of only 1.1 to 1.3 gives you 25 to 75% more parts per pound of stock.

OPENS UP THOUSANDS OF NEW APPLICATIONS

- in the aircraft industry, automotive industry, process industry, electrical and electromotive industries.

Wherever good mechanical strength and good dielectric properties are required at temperatures far above and below the limits of any other rubber-like material.

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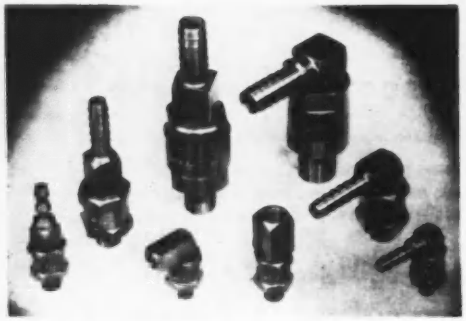
Dow Corning
FIRST IN SILICONES

the saving in space has allowed all dimensions to be reduced. Life-Seal ball bearings are used to give years of service without lubrication. Motors are available in single phase from ½ through 3 hp and in polyphase from ¾ to 3 hp. Temperature rating is 55 C for continuous duty.



Swivel Connectors

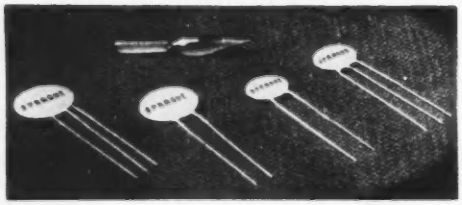
The Cleveland Vibrator Co., 2774 Clinton Ave., Cleveland 13, Ohio.

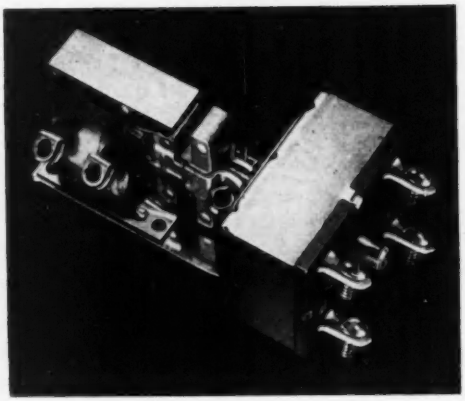
This new line of air-tight swivel connectors is used with air hammers, grinders, chippers, rammers, pneumatic wrenches, spray guns and other portable air-powered tools. When used at the air intake connection these connectors provide a full 360 deg swivel action which eliminates wrist strain for the operator and prevents unnecessary kinking and buckling of air feed lines. Tool changing is also made easier and more rapid. Made of rust-resistant steel, connectors are available in straight or ell types to fit hoses from ¼ to 1 in. and pipe from ⅛ to 1 inch. These are stock sizes.

Thin Disk Ceramic Capacitors

Sprague Electric Co., North Adams, Mass.

New capacitors consist of a dime-sized ceramic plate of extremely high dielectic constant with silvered electrodes fired on both faces of the disk. Uni-directional leads are soldered to the silvering and the capacitors are coated with a tough, moisture-resistant insulating resin. This construction makes for a neat fit across miniature tube sockets and gives the unit good efficiency as a high-frequency bypass capacitor. These disks have a high insulation resistance and are useful as coupling capacitors in low frequency circuits. They are available in ratings up to 0.01 mfd for the single type and 0.004 mfd on each side of the doubled type, 500 v, direct current.





Solenoid-Operated Switch

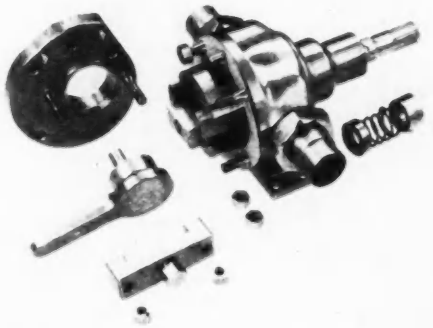
Soreng Mfg. Corp., 1901 Clybourn Ave., Chicago 14, Ill.

Unit consists of normally open DPST switch, with a powerful solenoid used as the actuating mechanism. The switch can be used for a variety of current control applications. High current-carrying capacity, small size and totally enclosed contacts are featured. Arcing is minimized by high contact pressures and large-area double-break contacts.

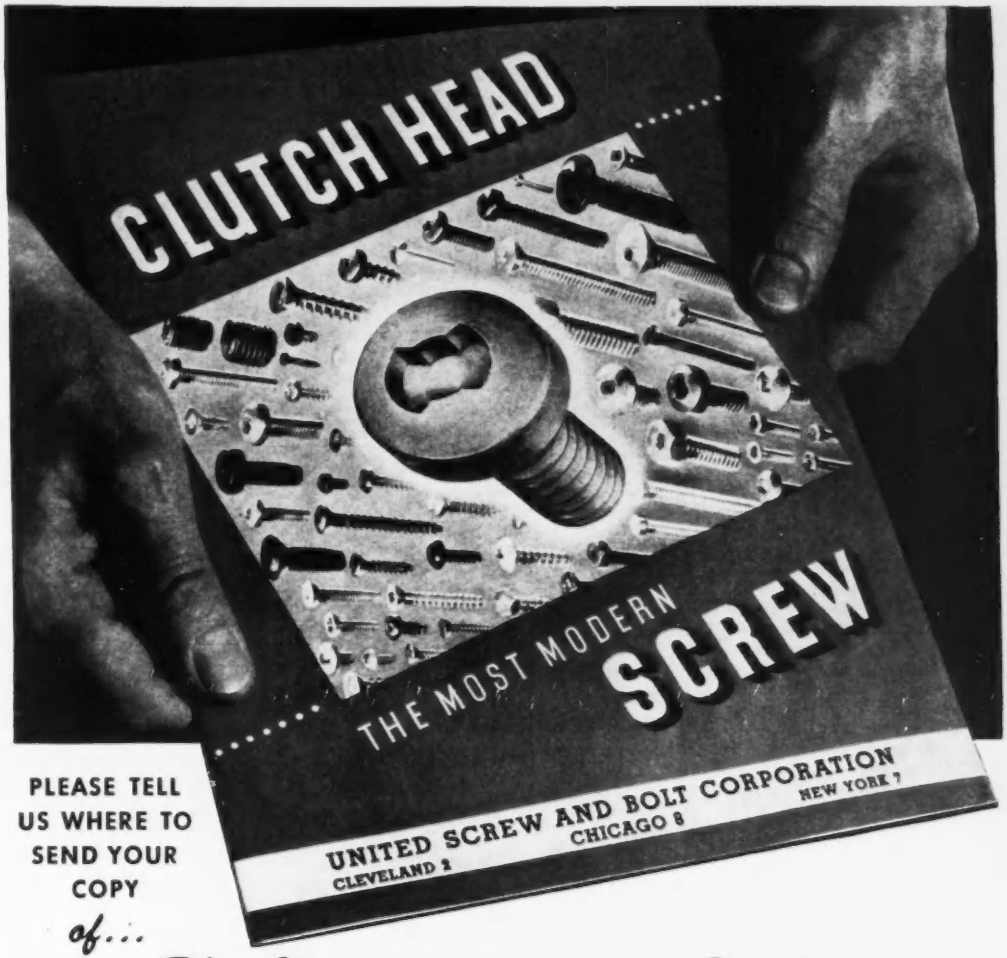
Tri-Rotor Sanitary Pump

The Yale & Towne Mfg. Co., 200 Henry St., Stamford, Conn.

This new nickel alloy pump is designed especially for the pumping of milk, liquid foods, and other materials that must not be contaminated. These units will not harm liquids by chewing, foaming, or overheating. They are furnished with a manually operated variable volume control which eliminates the need for a variable speed drive.



A solid head can also be furnished for applications where the volume control is not needed. The control will allow a flow ranging from 40 gpm at 575 rpm to 0 gpm, without stopping the unit. Pumps are supplied with 2 in. ports.



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A Frictional Lock-on, joining screw and bit as a unit, to permit easy placement and one-handed driving at "fumble spots."

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Please attach coupon to business letterhead and mention sizes and types of screws in which you are interested.

Magnetic Counter

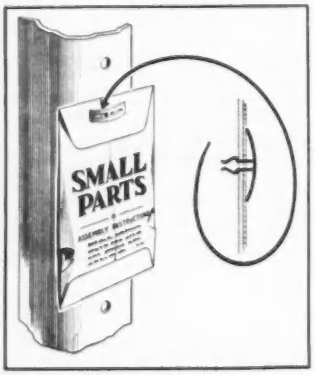
Abrams Instrument Corp., Lansing 1, Mich.

This three or four digit precision counter measures only 1 in. high, less than 2 in. deep, and weighs 2 oz. The unit has high utility wherever space limitations are present since the additive or subtractive counter wheels record up to 1,200 counts per minute. The figures are either white or fluorescent on a black background. Each wheel can be reset manually. Actuated through electro-magnets, these counters can be connected in vacuum tube plate circuits, or can be operated by any contacting device. Standard coils are 24 v d-c or 110 v d-c. The case is die cast in smooth black lacquer finish.

Small Parts Clip

Tinnerman Products, Inc., 2035 Fulton Rd., Cleveland 13, Ohio.

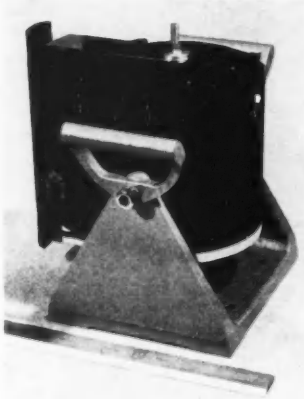
Speed clip is used to attach fasteners and small parts to knocked-down assemblies. Parts are put in a paper envelope and quickly clipped to the assembly for shipping purposes. They are recommended to makers of steel shelving, steel furniture, appliances, and other knocked-down metal products.



Electro-Dynamic Shaker

The Calidyne Co., 751 Main St., Winchester, Mass.

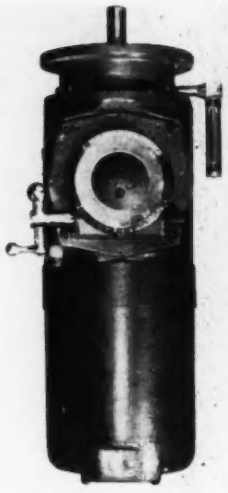
This new shaker is used for generating oscillatory linear motions or forces in vibration resonance testing, fatigue strength determinations and in other applications where large vibratory forces over a wide frequency range are required. Designed specifically to give a high force output for its size and weight, the unit can be moved to exert forces in any required direction. Maximum force rating, at any frequency, is ±25 lb. Power output at 60 cps is ¾ hp, and total weight, including trunnion base and handles, is 60 lb. There is a field supply of 115 v d-c and 0.5 amps, with lower voltage fields available on special orders.



Variable Speed Transmission

Graham Transmissions, Inc., 3754 N. Holton St., Milwaukee 12, Wis.

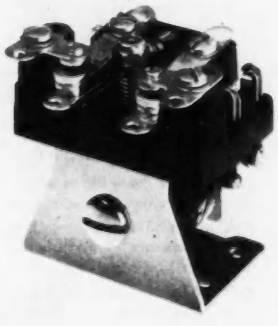
The type F vertical flange mounted variable speed transmission has a speed range from 0 to 1,100 rpm. It is particularly useful for mixing applications where a change in viscosity occurs, and for motoring and proportioning uses. The micrometer control allows extremely accurate speed settings which are maintained even under variable loads. The unit has standard NEMA flange mounting dimensions, and can be furnished with a special shaft extension. The transmission is available without a motor, or with a 1,800 or 3,600 three phase or capacitor start-induction run motor.



General Purpose Relay

Advance Electric & Relay Co., 1260 W. 2nd St., Los Angeles 26, Calif.

Designed for a wide variety of commercial, industrial, portable, and military installations, the small size of this new relay makes it ideal for plug-in or hermetically sealed requirements. The contacts on standard units are ¼ in. dia pure silver. Rating is 115 v a-c or 24 d-c non-inductive. Units are available for any operating voltage up to 300 d-c or 440 a-c. For higher loads special alloys are available. These relays have a molded bakelite insulation, and have an arma-



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for Chain Makers
The purpose for which a chain is made determines to a great extent the type of steel used in its manufacture. Sharon Steel metallurgists have *a background in chain making* that assures manufacturers of the right steel for the right job. That's one *important* reason why the Sharon Steel Corporation is the nation's largest producer of alloy steel for chains.
SHARONSTEEL

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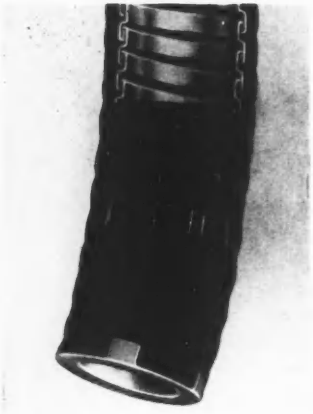
ture and frame especially designed for operation under extreme vibration and shock conditions. Metal parts are heavily plated with cadmium or nickel. The universal wound coil is vacuum varnish impregnated.

Wiring Conduit

American Brass Co., Waterbury, Conn.

Sealtite electrical wiring conduit consists of flexible, galvanized steel tubing covered with a smooth abrasion resistant, moisture and oil proof protective jacket made from Geon plastic. Sizes run from ⅜ to 2 in. Can be

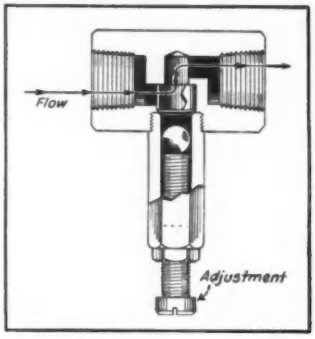


used with machine tools, paint manufacturing, chemicals, plastics and textiles, to protect wiring exposed to moisture, oil, acid fumes, grease and dirt. Furnished in long lengths to be cut and assembled by user.

Velocity Limiting Valve

Pneu-Trol Devices, Inc., 3122 *N. California Ave., Chicago* 18, *Ill.*

Valve is used to control top limits of velocity and volume in air or gas lines. It can be set for a wide range of pressure calibrations, and will shut off flow of gas when the desired setting is reached. A stainless steel ball is pulled up against its seat and held in the closed position by line pressure whenever the flow exceeds the setting. When the pressure is exhausted, the ball drops off its seat and re-sets itself. Screwing the adjusting screw in or out of the valve lowers or raises the pressure setting at which the valve closes. It is available in ¼ in. pipe

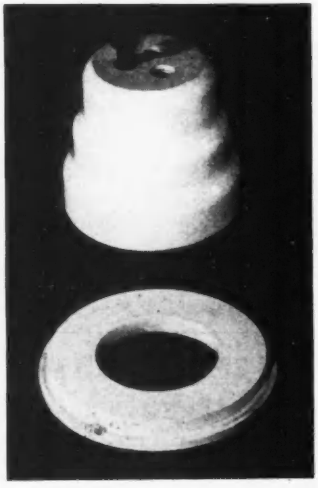


size (other sizes are a special order) and is made of brass bar stock with stainless steel parts and internal fittings.

Industrial Ceramics

Coors Porcelain Co., Golden, Colo.

A new class of industrial ceramics recently developed have the properties of heat, corrosion, friction and abrasion resistance. These ceramics are designed to be used for high pressure valve parts, bearings, grinding balls, nozzles, surface plates, plug and ring gages, pump parts, and high frequency insulators. These materials are custom made with extremely close tolerances and fine finishes. One of these ceramic materials has a tensile strength of 25,000 psi, compressive strength of 290,000 psi, a coefficient of expansion about half that of steel, a specific gravity of 3.63 and a hardness comparable to natural sapphire.

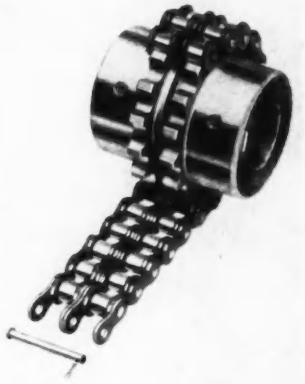


The coefficient of friction for all types is extremely low. Finished products are normally supplied ready for assembly, due to the special finishing process required by these extremely hard materials.

Chain Couplings

Morse Chain Co., 7601 Central Ave., Detroit, Mich.

The series DRC double roller chain coupling has a new single connecting pin design for easier assembly or disassembly. These chain couplings are made in 7 sizes ranging in capacity from 2.7 to 97 hp per 100 rpm and have a wide range of finished bore



diameters. Chain couplings are compact and are easily installed and aligned. Standard couplings allow for slight angular or parallel misalignment, while some special couplings are specifically designed to correct for misalignment.

Fractional HP Motor

Electric Motor Corp., Racine, Wis.

Model 700 electric motor can be series wound for the exact power a product needs, from 1/15 through ½ hp for continuous duty, or ¾ hp for intermittent use. When shunt wound, the motor has an intermittent duty rating of ½ hp. It can also be wound for voltages ranging from 6 to 230, d-c or a-c d-c. Its housing can be ventilated or totally enclosed, with black enamel, crackle or special finish. Rotation is clockwise, counterclockwise, or reversible, depending on product requirements. The standard shaft dia is ⅜ in., but virtually any shaft length

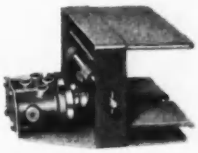
Small ★ Fast ★ Efficient

Hanna

Pilot Valves

CAM OPERATED

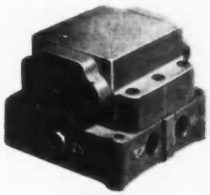
PUSH BUTTON



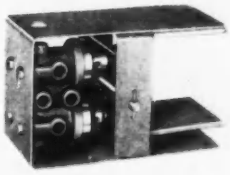
DOUBLE FOOT PEDAL

★ FOR DIRECT CONTROL OF SMALL CYLINDERS

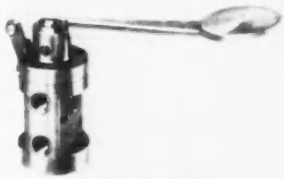
★ FOR AUTOMATIC CONTROL OF LARGE CYLINDERS



MASTAIR



SINGLE FOOT PEDAL



LEVER OPERATED

★ Operated by cam, lever, push button or foot pedal, Hanna Pilot Valves offer convenient, dependable control of cylinders either directly or automatically through a Hanna Mastair Valve.

The Cam Operated Valve, ideal for automatic or semi-automatic control, has a spring loaded roller actuated by straight line or rotary cam. For fast, continuous or repeating operations the Hanna Lever Operated Valve is recommended. It can be used in circuits where safety is a factor. The Push Button unit is suitable for panel installations or for use where guards are required around a valve. All are 3-way.

Hanna 4-way Foot Operated Valves provide hand-free cylinder control—or automatic control of large cylinders through the Mastair. The double pedal unit gives full control of both directions of cylinders; single pedal offers semi-automatic control. The Mastair Valve is of the balanced spool type, controlled by one 4-way or two 3-way pilot valves.

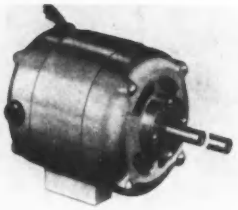
Send for New Catalog No. 251

It includes specifications and typical circuit diagrams and gives full information on Hanna's complete line of valves.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1765 Elston Avenue, Chicago 22, Illinois

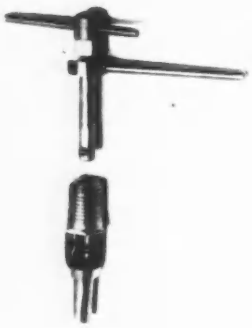


can be supplied. Bearings are available in two types—grease-sealed ball and porous bronze sleeve.

Tube Fittings

Midwest Fittings Co., 6225 Bartmer St., St. Louis, Mo.

Turn-Seal fittings are made for standard tubing in sizes up to 1¼ in. ID, and will withstand a hydraulic pressure up to 2,000 psi. A special tool (see illustration) is used to deform tubing inside the fitting and insure a tight seal. A Neoprene "O" ring provides further sealing protection. The special tool forces opposing balls



into the wall of tubing. The tool is then turned to seat tubing in the groove provided in the fitting. When tubing is well seated, the balls can be withdrawn into the tool, and the tool withdrawn, finishing the operation.

Electrical Insulating Laminates

Laminated Plastics, Inc., 14838 *Euclid Ave., Cleveland* 12, *Ohio.*

This new series of heavy-duty Fiberglas electrical insulating laminates have all the requirements of high-impact class B insulating plate materials plus flame resistance. They have high rigidity, impact strength, arc and flame resistance, heat resistance, and low moisture absorption. Plates in standard thicknesses from 1/32 to 1½ in., and standard sheets of 36 x 48 in. are available.

Terminal Block

Curtis Development & Mfg. Co., 4524 W. Madison St., Chicago 24, Ill.

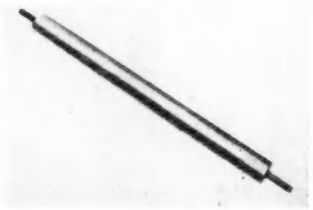
The type MT built-up terminal block has vari-colored fiber marking tags for harness or color coded wires. Since the terminal block is assembled with up to 24 terminals the colored fiber tags greatly simplify circuit tracing and assembly. These blocks have ample clearance and creepage distance

for use in circuits carrying up to 300 v, 15 amps. Each block has a solid base that provides more than sufficient insulation and is rigidly held in its metal channel. The block is easily mounted with screws or rivets and with little danger of damage or breakage.

Rubber Covered Rolls

The Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

Any size regular steel roll can be custom covered with silicone rubber to allow sheet plastics, metals, and fabrics to be processed at high or low temperatures. The silicone rubber remains soft and resilient within the temperature range of —100 to +500 F. These sheet materials may be run through the rolls into, or out of hot or cold dips, they may be squeezed to remove excess fluids, or they may be heat sealed. Since this rubber is resistant to the action of many chemicals, and has no plasticizers to affect chemicals, the photographic and chemical industries will find it of particular interest. The material has a high dielectric strength which is maintained at high temperatures. Static electricity does not build



up on the rolls, and the rubber will not carbon track in the event of an arc-over.

Self Locking Hex Nut

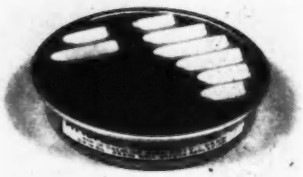
Townsend Co., New Brighton, Pa.

The new Tufflok Nut features a hexagonal locking insert to prevent it from rotating within the nut and assure a tight grip at all times. Also, the insert is chemically treated to resist both absorption of moisture and drying out which in the past has caused lock nuts to loosen. Another feature is the cold forging, adding extra strength to the nut body, and in combination with the tough insert providing an extremely tough nut which gives performance in excess of rigid Army-Navy requirements for aircraft fasteners. The Tufflok Nut is now available in sizes 4 through ⅜ inches.

Small Engine Air Cleaner

Pittsfield Products, Inc., 2275 Platt Road, Ann Arbor, Mich.

This newly designed air cleaner is for use with small engines and air compressors. It has an all aluminum casing for durability, appearance valve, and lightness. The filter medium is crimped copper. This copper crimp is filled by dipping in oil, and presents a



large surface area for dust retention. The simple design makes this unit adaptable for many applications with small engine carbureters and air compressors. Also, these air cleaners can be made up to meet the customers special requirements.

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THE CONTINENTAL DRIVE IS STRICTLY HAND DETACHABLE... REGARDLESS OF HOW SEVERE THE OPERATION HAS BEEN

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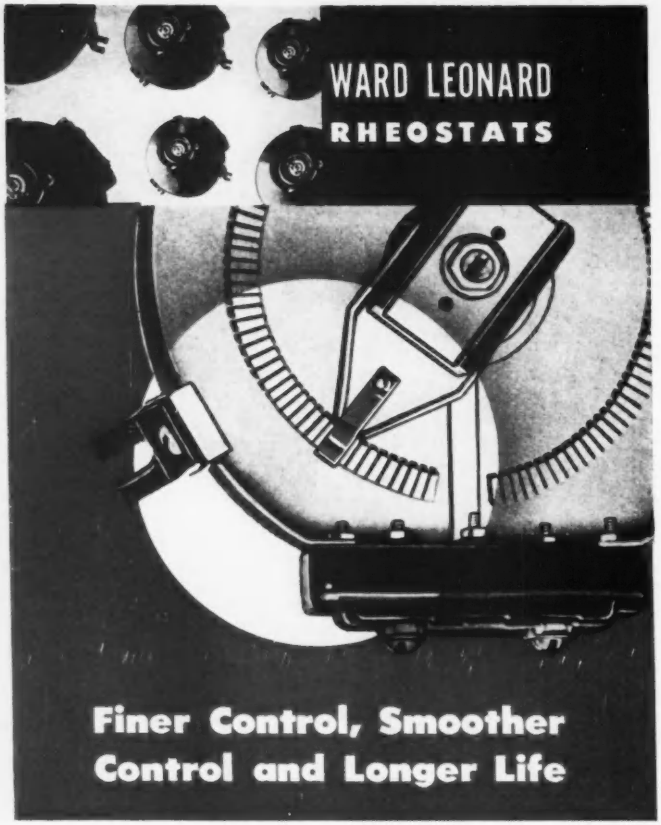

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because of solid rectangular contacts

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OUR READERS SAY

Is Our Patent System Falling Apart?

To the Editor:

Since PRODUCT ENGINEERING has shown an interest in Patent Office affairs, you might be interested in some of the opinions of one who has spent a great part of his life closely associated with the system.

Personally, I do not believe that we can get along without a Patent System, at least not in the U.S.A., any more than we can get along without pants.

Concerning the opinions that I have expressed in the article that I am sending you herewith, there is nothing even slightly official.

—J. HAROLD BYERS
Washington, D.C.

Ed.—Since the Patent System is one of the mainstays of our technology, and hence our Western civilization, we think the following article should be printed in full. Mr. Byers is now a patent examiner employed in the Patent Office. He has been doing patent work of some nature since 1927, having worked for the War Department during the last war, and having been in private practice. His B.S. and LL.B. degrees, together with his affiliation with the Patent Office Society, make him an authority on the subject.

What's Wrong With The Patent System?

In 1836 an inventor and statesman, the Hon. John Ruggles of Maine, secured the passage of the basic patent system legislation that we use today. Through the years two changes have taken place in this system. First, there has been a certain drawing apart of science and the patent laws. This is the inevitable result of specialization. In Washington's, as even Lincoln's, day, a man could be a scientist and president too. Second, there has arisen a lack of appreciation which seems to amount almost to antagonism on the part of influential bodies to the very objects of the patent laws. The question naturally arises, whether there is any connection between the lack of scientific background on the part of judges today, and the often repeated de-

preciation of scientific achievement that we find expressed in so many decisions by the courts.

The matter is far from being that simple. At the same time that the Supreme Court has been holding most claims of most patents that come before the court invalid, there has come into existence a strong current of decisions in certain other courts which considerably strengthen the position of the inventor without a patent.

What is the cause of this strange and erratic behavior? Where are the courts going?

Nothing seems to be wrong with American inventive genius. The quality and quantity of ideas submitted to the Patent Office far exceed those of the days when the Supreme Court was holding most claims of most patents valid.

Yet the "invalidity quotient" has slid sickeningly in the past decades. The table below clearly shows this decline. The statistical analysis is part of a study which in 1941 was presented to the Patent Bar of Chicago by the Hon. Evan A. Evans, of the U. S. Circuit Court of Appeals, 7th Circuit:

Table of Decisions by The United States Supreme Court in Patent Cases From 1900 to 1940

Period	Cases Heard	Held Valid	Held Invalid	Held not Infringed
1900-05	9	2	3	4
1906-10	7	3	1	3
1911-15	4	4	0	0
1916-20	16	5	9	2
1921-25	14	3	8	3
1926-30	12	3	5	4
1931-35	14	3	11	0
1936-40	15	0	13	2

Since 1940, the record has been equally bad. From 1941 to 1945, 18 cases were heard, and 2 patents held valid.

In defense of the courts it has been theorized that the Patent Office, overloaded and understaffed, put the squeeze on its staff to get out an inordinate amount of patents, and that these patents therefore were not carefully considered. It is true that the Patent Office has long been overloaded with work and understaffed, but there is no shred of evidence that the so-called "standard of invention" was lowered in any respect. Actually the standards of patentability of the Patent Office are higher today than at any previous time in its history.

If the Patent Office denies to an inventor allowance of his claims, he can, and many do, appeal to the courts, and if the courts reverse the Patent Office, the latter issues the patent. In short, the Patent Office follows judicial precedent and its stand-

because the shape is elliptical

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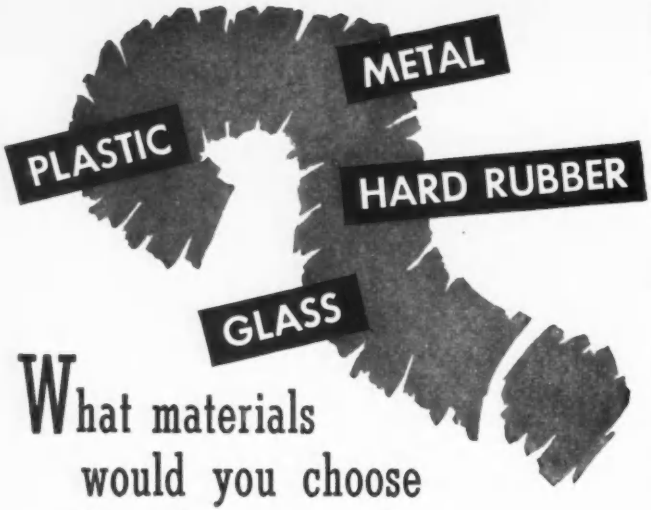
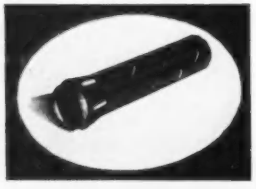
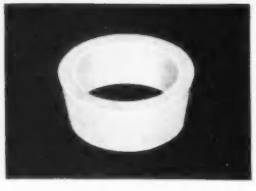


What materials would you choose for these parts?

1 **INDUSTRIAL FLASHLIGHT CASE:** Must be tough, good-grip, non-corrosive, oil-resistant surface. Should be electrically insulated. Plated, painted, imitation leather surfaces had been tried, but they corroded, chipped, or peeled. What material would *you* use?



2 Tapered gasket ring, exposed to acids, alkalies and essential oils, must impart no taste or odor to solutions. Must be free from "cold flow" for tight seal through a temperature range from 0° to 100° F. What material would *you* pick?



Answers: No. 1—Ace hard rubber, molded around brass tube, gives insulated, practically indestructible flashlight. No. 2—Ace Parian (polyethylene) is ideal for this gasket ring.

Yes, sometimes it's hard rubber, and sometimes it's one of the other plastics that's best. Ace, with many hard rubber and plastics compounds to choose from, is fully equipped to supply whatever you need. If you want this kind of impartial advice from your molder, select American Hard Rubber Company. Send for free 60-page Ace Handbook—a gold mine of helpful data.

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ards of patentability are imposed by the courts.

It is clear that those who are convinced of the necessity of the Patent System are on the defensive. They have no constructive program to improve the patent laws. With a few notable exceptions they want to retain every bolt on the old buggy just as it is.

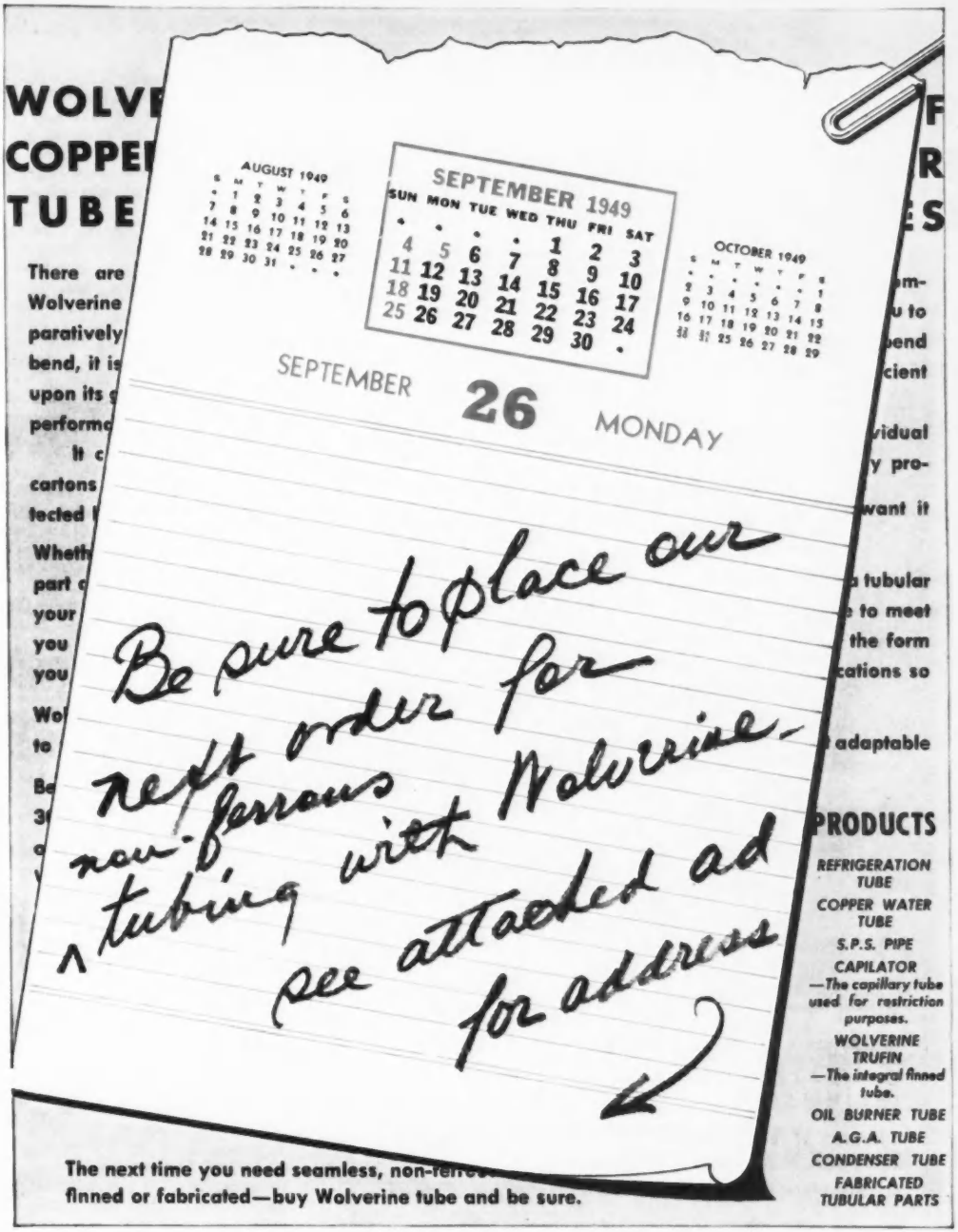
Those who are convinced that patents should be drastically curbed or abolished, are, for reasons best known to themselves, as busy as bees figuring out ways and means of getting the Patent System in the junk pile once and for all. With monotonous insistence they are hammering away at the idea that patents are monopolies. When an invention turns out to be a minor improvement it is described by these propagandists as a "monopoly" on a gadget. When an invention develops into something of widespread public value the inventor, if he has a patent, is accused of holding up important production. When an invention is marketed under a patent, the patent owners are accused of running a monopoly. When profits from patents are ploughed back into scientific research, more hue and cry of "monopoly" is raised. Apparently, the only disposition that an inventor can make of his patent that would satisfy the anti-patent crowd, is the waste basket.

A patent, of course, is not a monopoly. It is an exclusive right. The American Patent System is based on principles inherited together with, and from the same source as, the Common Law, Parliamentary Procedure, the Jury System, and other institutions implemented by the Constitution.

Normally the courts are the authorities who give direction and consistence to law through interpretation and it was to the courts that the Patent System looked for decisions controlling the issuance, character, and uses of patents. However, the decisions of the United States Supreme Court in recent years have astonished and appalled patent lawyers in the novelty of their premises. Judge Evan A. Evans said of these decisions:

> "The record of the Supreme Court during the last five years indicated not only a decided trend but a raising of the standard of patent novelty so high that few inventions or discoveries will meet the test."

If that were all it at least would settle the matter once and for all. We would just stop granting patents. But the lower courts, including those that are closely integrated with the Pat-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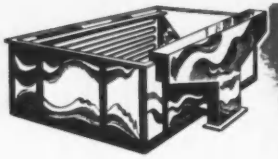

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IS ESSENTIAL

BUILD IT WITH
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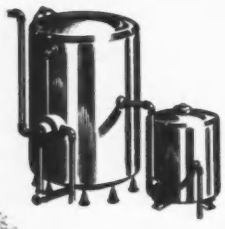

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Permaclad has excellent cold forming properties. It can be subjected to a considerably deeper draw than solid stainless without intermediate annealing.

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ent Office, are not well persuaded. Judge Evans adds:

> "If this standard be maintained by that (United States Supreme) Court, it will surely reflect itself in the decisions of the Circuit Courts of Appeals. For no matter how much larger the experience of the circuit judges, they will bow to the authority of the Supreme Court, even when they feel its decisions are harsh and unfair to inventors and their inventions and discoveries."

Exactly what does this mean?

It means that we have a fairly but not entirely settled "standard of patentability" derived from decisions of the courts in the late 1800's and early 1900's.

It means that we have intermediate "standards" in the Circuit Courts, depending upon how far they have progressed toward understanding what the Supreme Court is trying to accomplish. The Circuit Courts never have been of single mind, and no supposition is warranted that they will all make equal progress toward the lofty but undefined Supreme Court standard.

Just where does that leave the inventor trying to decide whether or not to take out a patent?

Just where does that leave the attorney, trying to advise a client?

Just where does it leave the Patent Office, desiring to issue only valid patents?

Just where does it leave the public, interested in new inventions, and in just how far it can go in development and production of patented inventions and improvements?

No matter how commendable the intent, neither the inventor, the lawyer, the Patent Office, or the public, can predict the interpretation that will be applied to the inventor's Constitutional right.

The Court of Customs and Patent Appeals has made the following comment:

> "In our opinion it is not within the province of the courts to establish new standards by which invention is to be determined. . . . Until Congress shall otherwise legislate, or the Supreme Court shall otherwise specifically hold, this court will continue to hold that if a process or thing constitutes patentable subject matter, is new and useful, and the process performed or thing produced would not be obvious to one skilled in the art, invention would be presumed

Tough—

BUT IT "BRUISES" EASILY!

Another Example of How Sponge Rubber Can Contribute

Even the biggest modern airliner has a comparatively tender skin. Unless padded in some way the metal edges of cargo loaders and boarding ramps could do a lot of damage banging and scraping its aluminum sides.

Here is another place where *Spongex* sponge rubber can do a job. As the "contact" material on a roller, used as a plain section of tubing, or attached directly to the nose of ramps and loaders, *Spongex* acts as a cushion against the side of the plane.

Solving special problems, like this, of cushioning, insulating, sealing, sound and vibration elimination is all in the day's work for *Spongex*. *Spongex* is used to improve an almost infinite range of products . . . from all kinds of molded seals and gaskets, motor suspension pads, seat cushions and backs, to weatherstripping and rubber parts in a thousand different shapes and forms.

Made by a company that has specialized in cellular rubber products for over 25 years, *Spongex* has high resiliency, uniform cell structure, and resistance to temperature extremes, moisture, dilute acids and aging, that is worth your serious consideration—for special problems or the improvement of present production. Check on it. Sponge Rubber Products Co., 123 Derby Place, Shelton, Conn. Sales offices in principal industrial centers.

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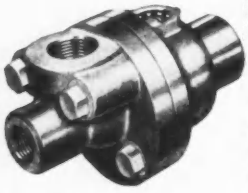
After several years of research and development, CHIKSAN is now ready with two new types of High Temperature Joints which represent the latest in design and performance. They are built specifically to answer the many problems encountered in the handling of steam and other high temperature fluids on rotating equipment and in flexible lines.



Maximum Working Pressure—150 lbs. steam.
1", 1½" and 2" sizes now available. Other sizes under development.
Cadmium Plated Chrome Seal Face.
Rotating speeds, 150 to 300 R.P.M.
Built to serve. Built to *last*.

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CHIKSAN HIGH TEMPERATURE ROTATING JOINTS

Designed and built for use on rotating drums, platens, tumblers, etc. This new Rotating Joint will handle steam, hot oil, water, brine, etc. Rotation may be constant or intermittent. The service may be hot or cold. A positive seal prevents leakage at all times. Packing chamber is hard-chrome plated. All parts are resistant to rust and corrosion.

Made in 8 different styles for turning in 1, 2 and 3 planes.
1", 1½" and 2" sizes now available. Other sizes under development.
Positive Metallic Seal.
Maximum working pressure 300 psi.
Maximum temperature, 600° F.

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CHIKSAN HIGH TEMPERATURE SWIVEL JOINTS (Metallic Seal)

These new Joints set new performance standards wherever steam or other hot fluids are handled through flexible lines. The Metallic Seal provides positive protection against leaks. Full 360° turning on stainless steel ball bearings which help to absorb radial and thrust loads. Unlimited flexibility is possible simply by arranging the swivels in proper sequence.

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BALL-BEARING SWIVEL JOINTS FOR ALL PURPOSES

and a patent may properly issue therefor."

The hope inferred is that either Congress or the Supreme Court will lay down a law or standard sufficiently specific to serve as a guide.

Can we look to the Supreme Court?

If we do it is a discouraging prospect. In recent years the Supreme Court is holding almost 100 percent of the patents that come before it invalid. In prior years, its decisions were friendlier, but unpredictable. The time has come to admit the truth. The patent laws, never perfect, but in past years commendably workable, have broken down. Whether we like it or not, we are confronted with the fact that the Patent System, old model, is stuck at the crossroads, and debating whether the horse or the driver is to blame is not going to get the system back on the road again.

This leaves us the alternative of legislation by Congress. Do we need new law?

The present basic law of patents was enacted in 1836. Prior thereto, it had been found necessary to change the law several times. Yet the law of 1836, now over a hundred years old, is with us yet, despite changes that have taken place in technology, economics, and policy.

Many points of practice have needed legislative clarification for years. The courts operate under limitations that prevent settlement of certain problems.

Obviously, if the Patent System is to continue to serve the public, patents must be held valid. It will not do to continue to experiment until the secret formula of validity is discovered by accident.

Congress can define in unmistakable terms the conditions that must be met in order to get a valid patent. Such legislative declaration would be binding on all the courts, and would render the practice uniform.

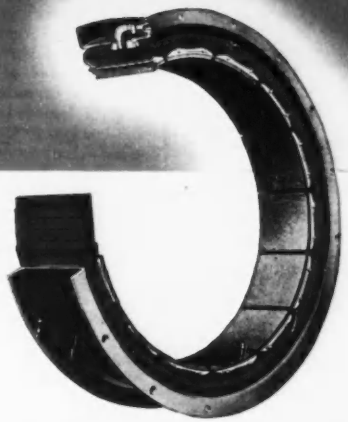
Congress is the body able and obligated to speak for the people. If we are going to abolish the Patent System, then let it be done decently and openly by Congressional action, and not by judicial attrition. If, on the other hand, it is in the interest of the public to grant patents, and today no country of any industrial consequence is devoid of a patent system, then Congress can lay down the law in such a way that the majority of patent grants will be valid. If there actually exist areas of conflict between our patent laws and other just laws, the conflict should be resolved by Congress.

What are some of the basic changes needed?

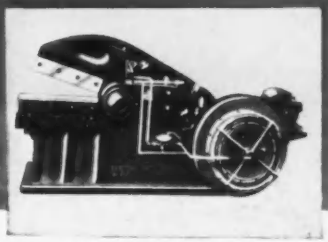
First, education as to the basic facts

ONLY ONE MOVING PART

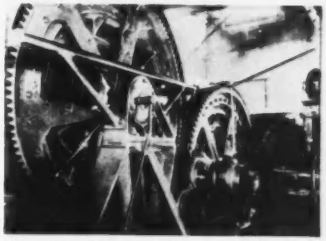
in this Fawick Clutch.



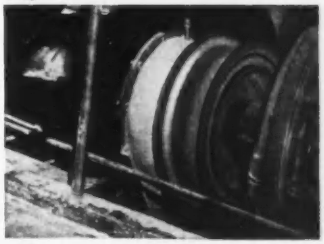
Fawick Airflex Clutch or Brake Type CB



Fawick Airflex Clutch and Fawick Air-Ring Brake on Canton 11A Shears made by Hill Acme Co., Cleveland, Ohio.



2 Fawick Airflex elements used for hoist drum and drag drum clutches on Marion Model 350 Dragline.



Fawick Airflex Clutch and Brake on two Farrel Birmingham 18 x 50 Mills at Goodyear Rubber Sundries Co., New Haven, Connecticut.

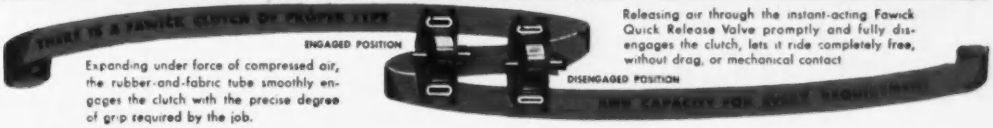
The rubber-and-fabric pneumatic tube faced with friction shoe assemblies is the only moving part in this Fawick Clutch. This part naturally stays in perfect adjustment at all times—automatically compensating for wear of the friction shoes.

Job-tested, Fawick Clutches meet the toughest operating conditions in many fields—petroleum, earth-moving, metalworking, rubber, paper, pulp and others.

Write our engineering department for a recommendation of the Fawick elements best suited for your machines. Address Dept. PE.

FAWICK Airflex CO., INC.

9919 CLINTON ROAD CLEVELAND 11, OHIO



Expanding under force of compressed air, the rubber-and-fabric tube smoothly engages the clutch with the precise degree of grip required by the job.

Releasing air through the instant-acting Fawick Quick Release Valve promptly and fully disengages the clutch, lets it ride completely free, without drag, or mechanical contact.

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...to save assembly time

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* ***LAMINUM*** (Reg. U. S. Pat. Off.) shims are solidly bonded units made up of .002 or .003 inch brass or steel laminations with a microscopic layer of metallic binder. Cut to your exact specifications.

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of the Patent System—what it is, why it exists, what it is supposed to do.

Next, legislative definition is needed on the criteria of patentability. To be patentable a thing must be new. But there are many hazy points as to what constitutes newness. To put the question simply, should we grant the patent to the first to think of the invention, the first to make the invention, the first to communicate the invention to the public, or some other, or some combination of criteria of novelty.

Legislative definition is necessary to dispose of the welter of confusion about "inventiveness," "mere mechanical skill," "genius," etc. I do not necessarily favor or believe operative the possibility of a legislative "definition of invention." In our present state of knowledge concerning inventive genius, it would appear that we could give serious consideration to abolishing the requirement altogether, or at least undertake issuance of a species of patent in which the criterion of "more than mere mechanical skill" had no part.

Should the practice of granting each and every patent for a fixed period of seventeen years be modified?

Should the field of patentable matter be broadened? At present, for example, the discoverer of a new and valuable use for an old compound, in trying to get some kind of valid protection on his discovery, is liable to end in financial ruin due to legalistic uncertainties.

How about making patents incontestible after a stated time?

The presumption of validity should be strengthened. The requirements that an applicant has to meet in order to satisfy the arms of government that he has a sustainable right should be nailed down in such a way that after the grant the matter remains fairly well settled. Some reasonable limits should be placed on the present powers of the courts to hold patents on meritorious inventions invalid for want of qualifications primarily technical and procedural. Something should be done to dispel or clothe with rationality the presently wholly mysterious requirement of "invention." Rubber yardsticks of patentability should be stiffened or abolished. Thresholds of patentability should be delineated. The scope of subject matter that can be protected by patent should be broadened and weaned from horse and buggy concepts.

Formal matters, for example, the matter as to whether an inventor can take out one patent on two inventions, or two patents on one invention, and

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the circumstances attending, can be whittled down to simplicity, and should be given some attention by Congress.

Just where the public interest in patents begins and ends should be discovered with some degree of intelligibility. The concept that best serves the ends of justice and the public interest should be nailed down with legislation.

If Congress decides that the American Patent System is worth retaining, then the burden of single-handedly keeping the system rolling will be taken from the shoulders of the overloaded Patent Office. Well advised patent legislation ought to receive enthusiastic support from the entire patent profession, as well as from all whose interests would be advanced by an improved Patent System.

Which Plastic?

To the Editor:

I am a regular subscriber to "PRODUCT ENGINEERING and have found the magazine to be of the greatest help in my position as a design engineer and in just keeping up with engineering in general.

I have recently come across a rather unusual problem and I felt that perhaps you might be able to help me directly or recommend where I may possibly find an answer.

I am looking for a plastic which is manufactured in sheet form, $\frac{1}{32}$ or $\frac{1}{16}$ in. thick. It must be pliable and bend through 180 deg. without cracking. The color is a secondary consideration but it would be desirable to have it manufactured in a number of colors including transparent. It must adhere to cloth upon application of heat at a temperature which will not be injurious to fabrics (including rayons, wools, silks, and cottons).

I would appreciate all help you can possibly give me on this problem.

—JACK YOUNG
New York

Ed.—You might try a flexible vinyl plastic. Another possibility is polyethylene. To make certain that you use a material exactly suited to your needs, you can contact the Technical Service Department of the Bakelite Corporation at 30 East 42nd Street, New York. This company markets both of these plastics.

Our Mistake

To the Editor:

I have just had an opportunity to look at my copy of July PRODUCT

ASK STOKES

AUTOMATIC MOLDING GUIDES TODAY'S PRODUCT DESIGNERS

HERE are just 12 of many different plastic parts designed by Pass & Seymour, Inc., Syracuse, N.Y. for low cost, high speed production on Stokes Automatic Molding presses.

Designers everywhere are under increasing pressure to create plastic parts that can be priced low enough to compete in the buyer's market . . . today's designs must permit savings in production costs and material.

Production costs are always low with Stokes automatic presses . . . one man can tend as many as six or more machines. Just the right amount of material is automatically metered into the mold . . . with obvious material savings and reduced rejects. Inventory is held to a minimum . . . production can be geared to daily requirements.

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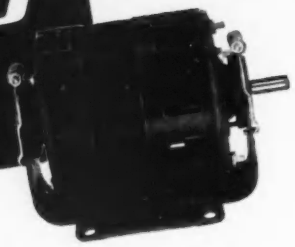

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ENGINEERING and observe that my inertia diagram had been published.

I might mention here that in the printed article the formula for $I_{c.g.}$ is given correctly in (3) the first time, but in the next one, $I_{c.g.}$ is written with the constant 0.02588. This should of course be 0.002588. The error also appears on the chart itself. I would request that you call attention to these as typesetters' errors in the next issue of PRODUCT ENGINEERING. HERBERT F. BARIFFI
New Haven, Conn.

Ed.—Of course Mr. Bariffi is right. We overlooked this error in our copy reading.

And Another One

To the Editor:

While we appreciate the publicity given to Hi-Speed-It in your July 1949 issue, in which you print a reply to a letter from Mr. Benham of Porter-Cable Machine Company under the heading "How to Harden a Nail," we must point out that sole manufacturer of Hi-Speed-It is our client, Wilson Carbon Company, Inc., 60 East 42nd Street, New York, N. Y. and not Carbon Products Company as you have stated. We know of no such company.—IRWIN W. TYSON
New York

Ed.—Well, we had the address right at any rate. We are sincerely sorry to have steered any reader to a non existant company.

Use of the Magnetic Fluid Clutch

To the Editor:

I was extremely interested in your article on the magnetic fluid clutch in the June news section of PRODUCT ENGINEERING.

Since I am thinking of using such a clutch in connection with servo mechanisms, I wonder who holds the basic patents, and just what procedure a person has to go through to make legal use of the idea.

Any information you can give me on this point will be appreciated.
—MILLARD W. WAGNON
New York

Ed.—Checking with Mr. Jacob Rabinow, Chief of the Ordnance Mechanic Section, National Bureau of Standards, we find that these patent rights are in the public domain. Anyone can apply the clutch in any way he chooses as long as it is for domestic use. Mr. Rabinow holds the foreign rights on the clutch.

NEW MANUAL

contains latest information on

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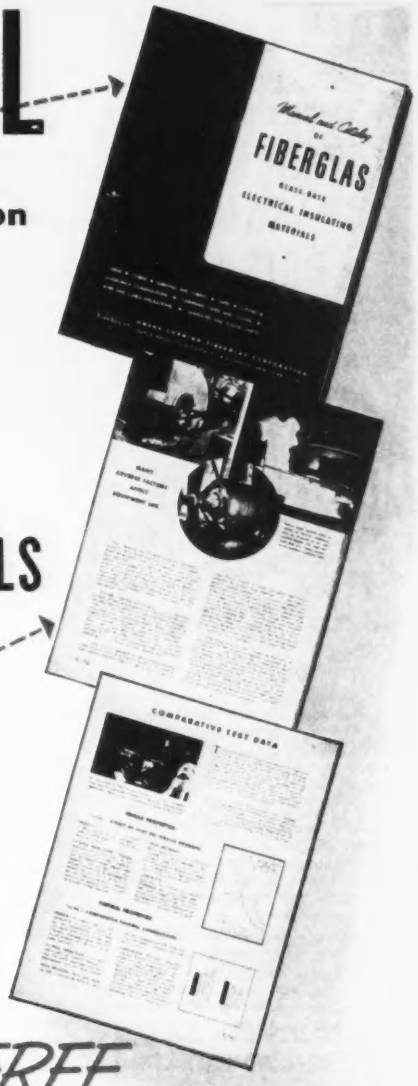

The new 36-page "Fiberglas Glass-base Electrical Insulating Materials" manual is just off the press. Contains performance charts, graphs, photographs and descriptive material on the complete line, including: Tape, Varnished Cloth, Saturated Sleeving and Varnished Tubing, Yarn, Cord, Braided Sleeving, Cloth, Laminates, Mica Combinations and Wire and Cable Insulations.

Features selection factors—suggested uses—and other pertinent information that will help you determine the best Fiberglas-base material for a specific job. Lists the manufacturers of these insulating materials and tells you where you can buy them in your locality.

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INSTRUMENT SOCIETY OF AMERICA—Annual Meeting; Municipal Auditorium, St. Louis, Missouri.

September 12-16
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Industrial Instruments and Regulators Division Conference and Exhibit; Municipal Auditorium, St. Louis, Missouri.

September 13-15
SOCIETY OF AUTOMOTIVE ENGINEERS—Tractor Meeting; Hotel Schroeder, Milwaukee, Wisconsin.

September 26-28
NATIONAL ELECTRONICS CONFERENCE; Edgewater Beach Hotel, Chicago, Illinois.

September 28-30
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Fall Meeting; Lawrence Hotel, Erie, Pennsylvania.

September 29-30
THE MAGNESIUM ASSOCIATION—Summer Meeting; Greenbrier Hotel, White Sulphur Springs, Virginia.

October 5-8
SOCIETY OF AUTOMOTIVE ENGINEERS—Aeronautic and Aircraft Meetings and Engineering Display; Biltmore Hotel, Los Angeles, California.

October 10-14
AMERICAN SOCIETY FOR TESTING MATERIALS—West Coast Meeting; Fairmount Hotel, San Francisco, California.

October 17-21
AMERICAN SOCIETY FOR METALS—Thirty-first Annual Meeting and Exposition; Public Auditorium, Cleveland, Ohio.

October 26-27
FIFTH ANNUAL NATIONAL CONFERENCE ON INDUSTRIAL HYDRAULICS; Sheraton Hotel, Chicago, Illinois.

October 31-November 2
PACKAGING MACHINERY MANUFACTURERS INSTITUTE—Seventeenth Annual Meeting; Edgewater Beach Hotel, Chicago, Illinois.

November 2-4
AMERICAN SOCIETY OF BODY ENGINEERS—Fourth Annual Technical Convention; Rackham Memorial Building, Detroit, Michigan.

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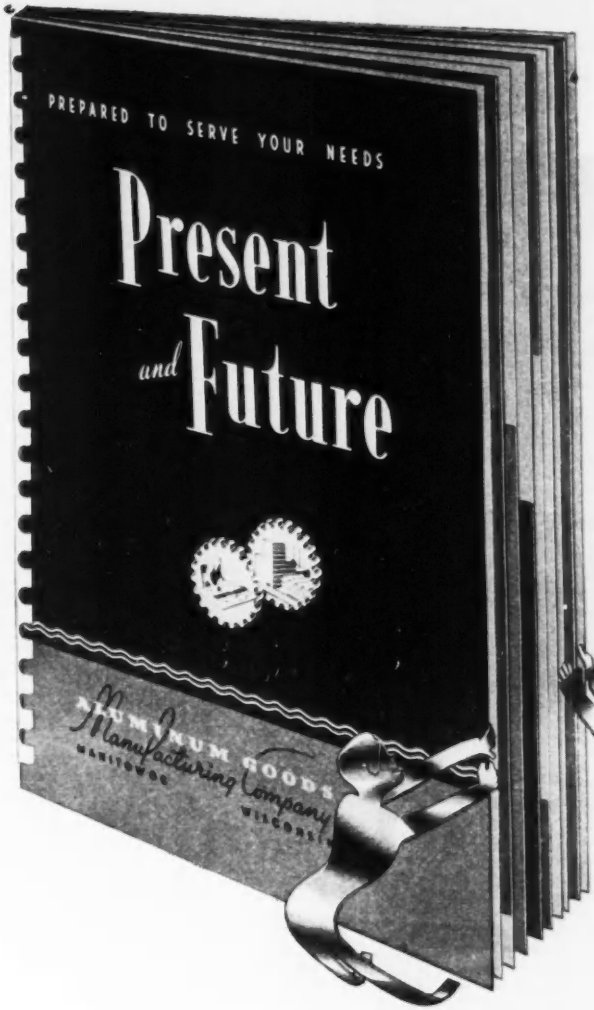

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NEW BOOKS

Constructive Uses of Atomic Energy

5½ x 8¼ *in. Published by Harper and Brothers, 49 E. 33rd St., New York 16, N. Y.* \$3.00.

S. C. ROTHMAN, *editor.* 185 *pages.*

Written for the intelligent layman, this book serves as well those readers who have some technical knowledge of atomic physics, but who are interested in a review and correlation of their special information.

Each chapter is written by a separate expert in that particular field. The reader will recognize such names as Arthur H. Compton, L. W. Chubb, Samuel K. Allison, M. Blan, J. R. Carlin, and many others.

For those who learned their physics in the days when an atom had only electrons, protons and neutrons, the chapter on "The World Within the Atom" will be a good, understandable review which will bring such a reader up to date on the latest atomic concepts. Those who know one phase of atomic research in great detail will find that this book gives a good survey of all the other specialized fields. A reader who uses tracers in the field of biology, for example, will be able to see what is being done with tracers in metallurgical research. There are chapters to cover all fields, from atomic aircraft engines to agriculture and fertilizer research.

At the end of the book there are three important appendices: a chronological list of highlights significant to atomic energy, a glossary of some important scientific terms used in atomic energy, and a bibliography. The book is also completely indexed.

Machine Tool Selling

HARRY J. LOBERG. *Professor and Head, Department of Industrial and Engineering Administration, Sibley School of Mechanical Engineering, Cornell University.* 198 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y.* \$3.50.

The basic material for this book came from a sales refresher course sponsored by the National Machine Tool Builders' Association and the American Machine Tool Distributors' Association. Although this refresher course covered most phases of machine tool selling, the author has

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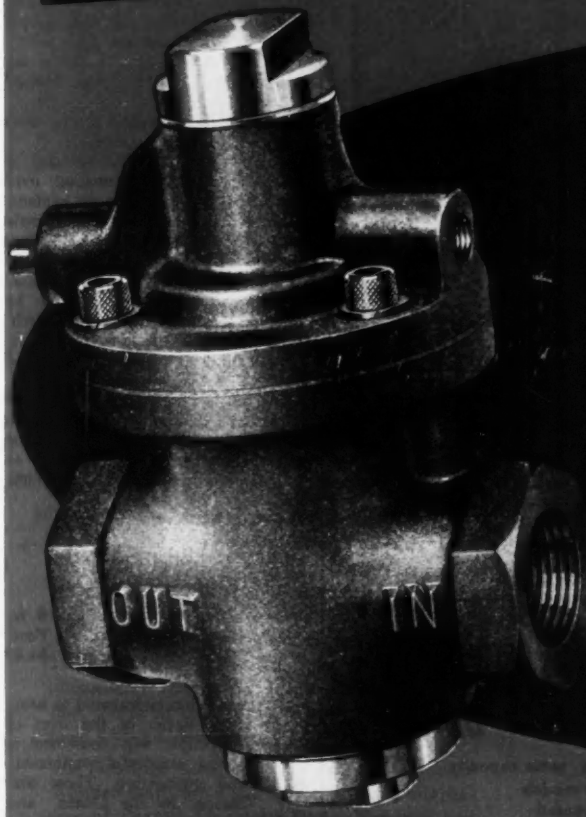

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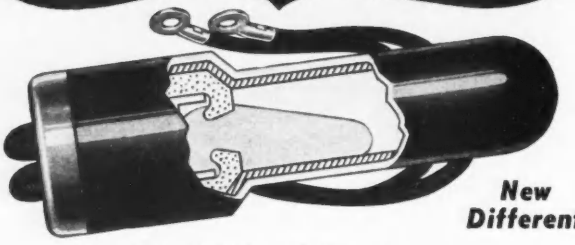

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added new material of his own and edited the original material to produce a comprehensive survey of the whole field.

Throughout the book interesting case histories are used to illustrate and emphasize principles, point by point. Mr. Loberg doesn't simply list things to do and things not to do, in the usual text book way—he teaches by example.

Beginning with a survey of the whole machine tool industry, the book next states the four principles of machine tool selling. They are:

1. The origination of an inquiry.
2. The selection of the proper equipment to be quoted.
3. The presentation of the quotation including the economic analysis of the purchase.
4. The follow-up and service after an order has been received.

Although the book contains a wealth of detailed information, most of it can be classified as an explanation or amplification of these main points. Some of the chapter headings are: Personal Qualifications of Salesmen, Analysis of Customer Personality, Selecting the Equipment to be Offered, Meeting Objections, Techniques of Sales Engineering Interviews, Selling to the Government, and many other such related subjects.

For the newcomer or the seasoned veteran the book will give a wealth of advice and guidance based on the practical experience of hundreds of salesmen and tool users over many years.

Frank and Lillian Gilbreth, Partners for Life

EDNA YOST. 360 *pages,* 5¼ x 8 *in. Published by ASME, New York, N.Y.* $5.50 *non-members,* $4.40 *members.*

The author has endeavored to bring together the stories of the lives of these two people who combined to make such a wonderful partnership of life and engineering. Those who read "Cheaper by the Dozen" and wish to have a complete story of the Gilbreth activities and careers will be greatly interested in this volume.

Frank Gilbreth is an inspiration to any professional man. He started as a bricklayer and within ten years was an independent contractor, owned at least two very profitable inventions and had a highly succesful construction business. He was a magnificent organizer, and it is impossible to read his story without realizing that his was a unique mind, inquiring, energetic and constructive to a wonderful degree. His wife's abilities are

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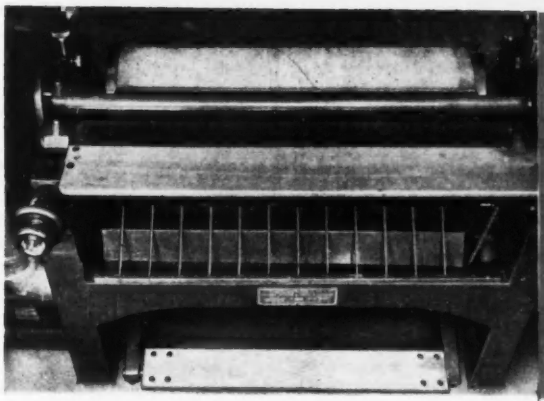

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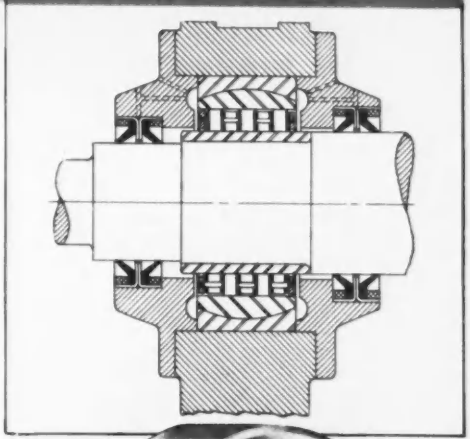

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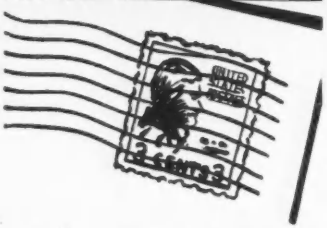

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fully as great. Together these two people have made a wonderful contribution to the world.

Engineers who want to learn how these two great leaders of industrial engineering built their careers will appreciate this book.

Maintenance Manual of Electronic Control

ROBERT E. MILLER, *Sales Mgr., Weller Manufacturing Co. First Edition,* 304 *pages* 6 x 9 *in. Published by McGraw-Hill Book Co., Inc.,* 330 *W. 42nd St., New York* 18, *N.Y.* $4.50.

This is a practical installation, maintenance, and service manual for the electrical and electronic technician. The work first appeared as a series of articles in *Electrical Construction and Maintenance,* a magazine written to keep the electrical engineer abreast of new developments and methods in the field.

The book starts with the very simplest electrical circuits, then proceeds to the more complicated circuits of electronic motor control and welding control. It then explains the use and adaptation of tools and instruments for electronic equipment trouble shooting. It describes also the installation, maintenance and servicing of specific types of equipment—timing relays, time-delay relays, photoelectric relays, electronic motor control, welding control, furnace temperature control and mercury-arc rectifiers.

The book involves no mathematics but includes check charts and illustrative material on instruments and meters. Special treatment is given to the cathode-ray oscilloscope, including how it can be adapted for special purposes.

Thus manual should be useful to those with little knowledge of electronic control, as well as to those electronic specialists who wish to obtain a broader understanding of electronic control.

The Universe and Dr. Einstein

LINCOLN BARNETT. 131 *pages,* 6 x 8¼ *in. Published by William Sloane Associates,* 119 *W. 57th St., New York* 19, *N. Y.* $2.75.

This book is a report on what the men at the forefront of science know about the nature of the universe. It is written in a clear, straightforward style—without the stiffness characteristic of some science works.

The search for essential truth about the universe has been conducted in all realms, from the infinitesimally

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The operating head can be mounted in any of four positions. The roller arm is adjustable through 360° to 870 positive-lock operating positions. The switch is field-adjustable to operate to either right or left, or in both directions, with ample overtravel.

The switching element, with the MICRO SWITCH snap-action principle of operation, is securely sealed within a die cast housing. The actuating mechanism operates through a seal which gives the switch complete protection against dirt, dust or splash of oil or water. The switching element is easily replaceable.

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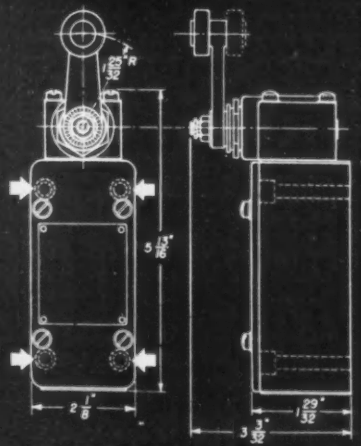
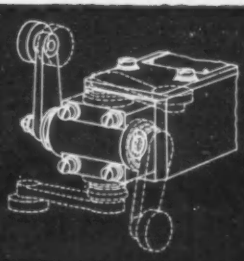
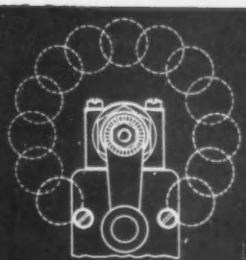


Four blind mounting holes for ¼" screws (shown by arrows) are provided in case—accessible with cover plate removed.



Operating head mounts in any of four positions shown. In addition, roller arm may be reversed as indicated.



Roller arm may be positively locked in any of 870 different positions at intervals of approximately 0.4°.

Operating shaft may be positioned for any one of the conditions of operation shown at right.

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SOLUTION: Blades of self-lubricating Morganite provided long service... no sticking... no chemical deterioration.

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The substantial savings on maintenance and replacement costs made possible in the operation of cooling compressors is only one example of Morganite effectiveness in increasing efficiency. Morganite valves, seals, rings, slides and other self-lubricating components provide a ready solution to many stubborn mechanical problems. Morganite has frequently offered the one practical answer to industry-old problems of design.

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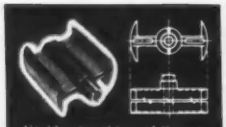
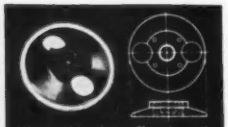


Liquid meter pistons of Morganite resist corrosion, will not gum or stick, are non-contaminating.



Morganite valves offer dependable pressure sealing, are immune to temperature fluctuations.

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small to the inconceivably vast, from the electron to the galaxy. Its leaders have been the great scientists and philosophers, and its tools many and various—from the pure mathematical equation to the cyclotron and the 100 in. telescope. The author tells the story of that search in the vocabulary of the intelligent layman.

Mr. Barnett excells in the art of "explanation by example." He explains the concepts of non-Newtonian physics with concrete, believable, and understandable everyday examples that give any intelligent reader a real picture of our strange universe.

As the title implies, the book deals mainly with the work of Dr. Albert Einstein. Although his name is a byword in our age, probably for the first time in our literature the average man can understand just what Dr. Einstein has done, what it means to world knowledge, and just how great a "great man of science" can be.

The reader who is curious about the universe of which he is a part will find such answers as Dr. Einstein and our science today are able to offer to the puzzle of what exists, and how, and when.

Strength of Materials

J. P. Den Hartog, *Professor of Mechanical Engineering, Massachusetts Institute of Technology. 323 pages, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St. New York 18, N. Y. $4.*

This is written as a text for a one semester first course in strength of materials. The first three chapters treat tension, torsion, and bending. The fourth chapter discusses combined stresses, including an explanation of the Mohr circle and a formulation of several theories of failure.

The next three chapters discuss deflection of beams, special beam problems, and cylinders and curved bars. The chapter on deflection places heavy emphasis on superposition. The chapter on special beam problems treats beams of two materials, skew load and center of shear, reinforced concrete, and plastic deformations. The chapter on cylinders and curved bars discusses both the cases where the ratio of thickness to radius of curvature is negligible and the case where it is not.

The book is concluded with three chapters on strain energy, buckling, and experimental elasticity. The chapter on experimental elasticity is made up of articles treating photoelasticity, wire strain gages, fatigue, and a further discussion of theories of failure. This discussion of theories of failure

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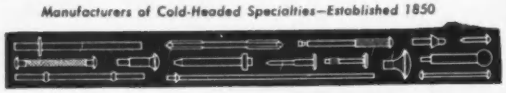

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includes a graphical comparison thereof for the case of biaxial stress.

To facilitate its use as a text, articles which may be omitted without destroying the continuity of the book are marked by an asterisk in the table of contents. In addition, the 350 problems in the back of the book are tied in by number with articles in the text. Answers to the problems and a list of the important formulas of the text are also given.

Industrial Uses of Radioactive Materials, A Selected Bibliography

Published by Arthur D. Little, Inc., Cambridge, Mass. 12 pages, 8½ x 11 in. No charge.

Beginning with a listing of survey articles on the subject, the bibliography then lists sources under specific use classifications.

Sources are listed under these main headings: The Petroleum Industry, Mining and Metallurgy, Textiles, Instruments, Radiography, Analysis, Pharmaceutical, Glass, Radioisotope Preparation, and Miscellaneous Industrial Applications.

Most of the references include a short summary of the material referred to.

Direct-current Armature Windings

CHARLES S. SISKIND, *Assistant Professor of Electrical Engineering, Purdue University. First Edition. 149 pages, 7 x 10 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y. $3.00.*

This book attempts to simplify the fundamental principles involved in winding modern d-c armatures. The completed armature, comprising the armature core, the commutator and winding, generally is regarded as an extremely complex structure. The study of its construction is, therefore, usually avoided. In this book, the author develops the subject logically and systematically in order to convince the reader that the subject can be broken down into a series of simple ideas.

The approach is new in several respects. Original simplified formulas are given for the calculation of the construction details of all types of windings. Testing procedures are described for the location of troubles in d-c armature windings. Many problems are worked out to show how windings can be modified to give changed operating characteristics. Di-

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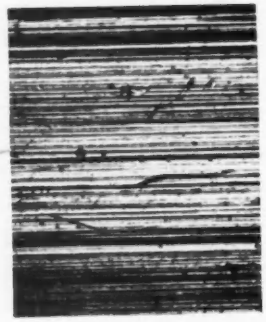
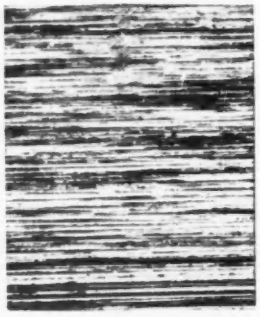
The photographs reproduced at the right are magnified one hundred times, so that you can see the difference between ground, polished and honed raceways. Hoover is America's only ball bearing with honed raceways. The process and the special machines for the honing operation, are exclusive, patented, Hoover developments. Hoover honing goes far beyond grinding and polishing to produce a surface that represents the closest approach to absolute perfection obtainable on a commercial basis.



GROUND RACEWAY SURFACE
(Photographed at 100 Magnifications)



POLISHED RACEWAY SURFACE
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HONED RACEWAY SURFACE
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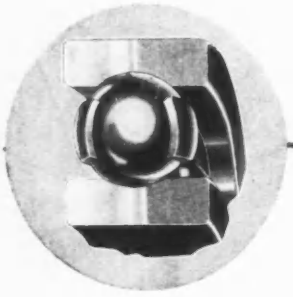

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HOOVER BALL AND BEARING CO., ANN ARBOR, MICHIGAN

agrams and sketches illustrate important principles. The author stresses the similarities and differences of the various types of windings and avoids confusion by using elemental illustrations rather than complete diagrams.

Sample chapters include: Progressive and Retrogressive Windings, Multi-element Wave Coils for Wave Windings, Multiplex-wave Windings, Frog-leg Windings and Voltage, Speed and Armature-winding Calculations.

Scientific Blacksmith

MORTIMER E. COOLEY, *Dean of Engineering, University of Michigan.* 279 *pages,* 6 x 9 *in. Published by ASME, New York, N.Y.* $3.75 *non-members,* $3.00 *members.*

This is an autobiography of a famous engineering educator, Mortimer E. Cooley, Dean of Engineering at the University of Michigan. Dean Cooley reminisces about the many experiences and acquaintances of a long lifetime spent in engineering work. Few engineers can hope to have such a long, full life.

Dean Cooley's early education was in up-state New York, and his introduction to engineering came when he enrolled in the United States Naval Academy, where he graduated in 1878. In those days there was no diploma covering a degree of Bachelor of Science, and it wasn't until 1937, nearly sixty years later, that he received his Bachelor's degree. Meantime he had been Professor and then Dean in the College of Engineering at Michigan.

The author did a great deal of the early work in public utility appraisal, and that chapter is among the most interesting in the book. In 1919 Cooley was President of the ASME. At various times he was a Director in the ASE, Vice-President of the American Association for the Advancement of Science, President of the Society for Promotion of Scientific Education, and President of the American Council of the Federated Engineering Societies. He was a member or an honorary member of so many organizations that it would require several pages to list them. With a world of contacts made in these activities, plus his active part in building the College of Engineering and Architecture at Michigan, Dean Cooley was bound to have had a vigorous and satisfying career.

His reflections and opinions on the engineer and the future are brought together in the last chapter which is by all odds the most interesting. Dean

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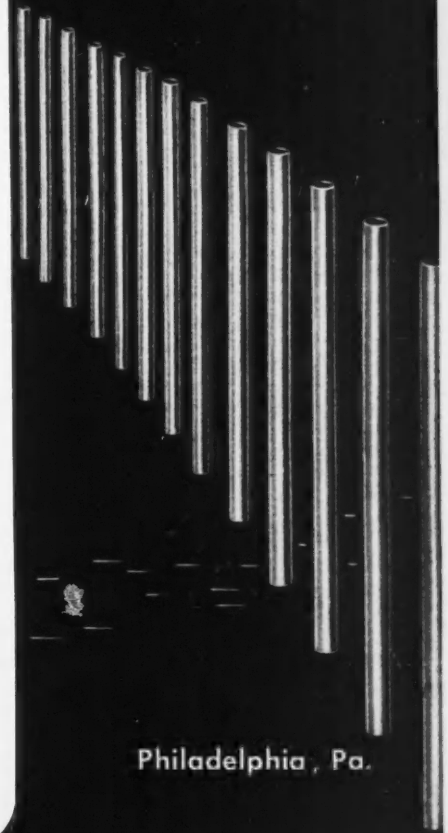

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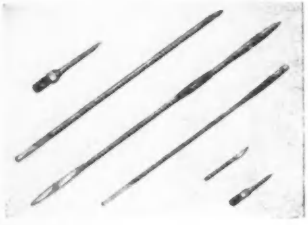

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Cooley feels that we are embarked on a policy of public ownership of national resources, public utilities and the manufacture and transportation of certain commodities. If this is true, then the engineer must step out of his role as a technical specialist and develop into a public servant trained in the solution of the technical questions which must be decided. The engineer, says Cooley, must step forth and assert and demonstrate his leadership in this field. His attitude toward the engineering profession and the engineer's future are summed up in the statement made in an address during World War I. As the author says, not a word need be changed to maintain the verity of his thought, "The war itself was brought about by the work of the engineer in the first place; and it is being fought and won by means designed by the engineer. I think if the engineer had the settling of the war it would be pretty well done; but it is going to be settled by other than engineers, and it won't stay settled, you can be sure of that." Dean Cooley's other great thesis is that the engineering profession must have a much broader education if it is to discharge its duties to industry and the public in general.

Introduction to Statistical Mechanics

RONALD W. GURNEY, *Visiting Professor of Physics, The Johns Hopkins University*. 6 x 9¼ *in.*, 268 *pages. Published by* McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y. $5.

Unlike the few existing books on the subject, which have been written primarily by mathematicians for mathematicians, this is an advanced text for graduate students of physics and chemistry. Against a background of atomic physics, the book studies the behavior of large groups of particles showing how the behavior of matter in bulk follows directly from the properties of the individual atoms.

The author has devised methods to enable the student to grasp the basic principles and the nature of partition functions. After the fundamentals are presented, the usual applications are made—to gases and solids, to saturated vapor pressure, a partially dissociated gas, a solid which can exist in alternative modifications, to order and disorder in crystals, to solutions and alloys, to imperfect gases, the condensation of a vapor, the chemical constant, and to Fermi-Dirac statistics and the free electrons in a metal.

A feature of the book is the treatment of metallic alloys, especially the

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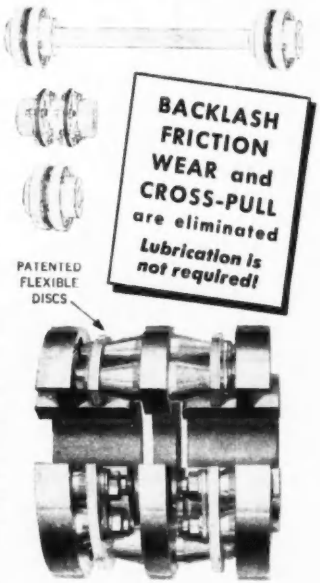

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solutions in the alpha and gamma phases of iron which form the basis of steel metallurgy. The author shows how the theory leads to the various types of behavior with which the metalurgist is familiar.

Each step in the argument is clearly explained, and a large number of diagrams included. Problems appear at the end of each chapter.

Sleeve Bearing Materials

A series of educational lectures on sleeve bearing materials presented to members of the A.S.M. during the Twenty-eighth National Metal Congress and Exposition. Edited by R. W. DAYTON, *Battelle Memorial Institute, Columbus, Ohio. Published by the American Society for Metals, Cleveland, Ohio.* $5.

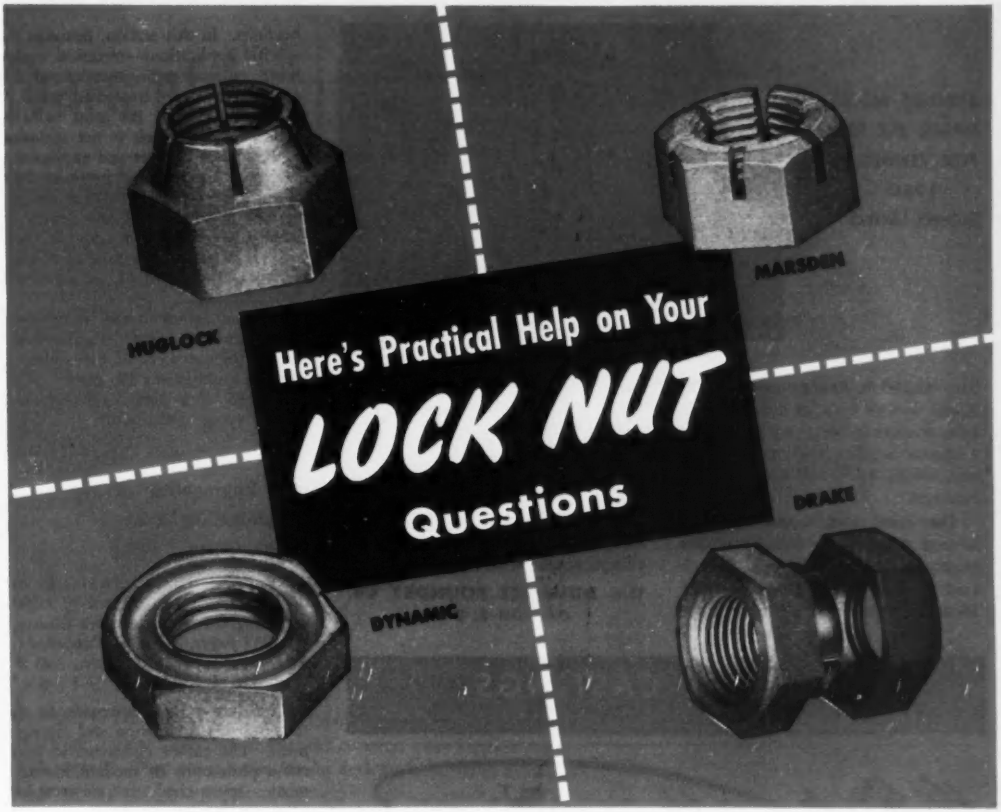
This book is a collection of relatively short discussion on the problems involved in selecting and applying sleeve bearing materials, and of the performance characteristics that can be expected in the completed bearing. As such, it is somewhat similar in make-up and treatment to previously published A.S.M. educational lectures —"Surface Stressing of Metals", for example.

The material has been grouped into four parts. These are: I, the nature of bearing materials; II, types of bearing materials; III, bearing structure and fabrication; and IV, the applications of bearings.

Part I, the characteristics of bearing materials, includes discussions on fundamental considerations, on the behavior of bearings, general comments, and on British thought and practice. Besides a short and somewhat general discussion on hydrodynamic lubrication, the sections contain data on the properties of conventional bearing materials and on the properties that a good bearing material should have.

Part II, specific bearing materials, places the emphasis on recently developed bearing materials and on those that have not received proper attention in the past. Silver bearings, aluminum and aluminum alloy bearings, grid bearings, cast bronze bearings, and bearings produced by the powdered metallurgy process are discussed in detail. While copper-base and babbitt bearings appear to receive little or no attention, references to them are made throughout other chapters. Furthermore, treatment of these as well as other types is included in Part III, Bearing Structures and Fabrication Methods.

Finally, Part IV is devoted to the factors involved in the application of



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bearings. In this section, bearings for specific applications—electrical equipment, railroad rolling stock, and aircraft engines—are treated in detail.

Perhaps one of the most valuable features of the book is the inclusion of references to texts and engineering articles in the technical journals. Such reference sections are placed at the end of each main part of the book. At the end of Part II, for example, there are 15 references on general bearing materials and some 43 on aluminum base materials.

Another feature is the inclusion of comments made during the discussion periods by members of the audience. Besides highlighting the major points of interest, these remarks tend to sum up the entire discussion.

The Engineering of Organization and Management

R. T. LIVINGSTON, *Professor and Executive Officer, Department of Industrial Engineering, Columbia University. 237 pages, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N.Y. $5*

This is a unique approach to the teaching of organization and management. The author endeavors to present a philosophy of modern management, approached as a complete theory rather than in terms of applications.

It is the author's contention that the area of management is the problem of coordinating the use of men, materials, and machines or processes in search of a common goal. To attain this, an association is formed which exists in an environment and must adjust itself thereto. With this as a premise, certain postulates are made, and the various required actions are compared with them. The cycle of management consists of five distinct steps: Decision, planning, preparation, action and review. Each of these steps can again be broken down into the same five steps.

It is stated that there are two coordinates—authority and sequence—and these five major steps, together with their subdivisions, may be located on these coordinates. When this is done, the pattern or the structure of management appears.

Thereafter, the major levels of command are explored in the light of its duties. Similarly, the major internal problems of the management are set forth in respect to the two coordinates. The book is offered as an approach to basic engineering as applied to engineering management.

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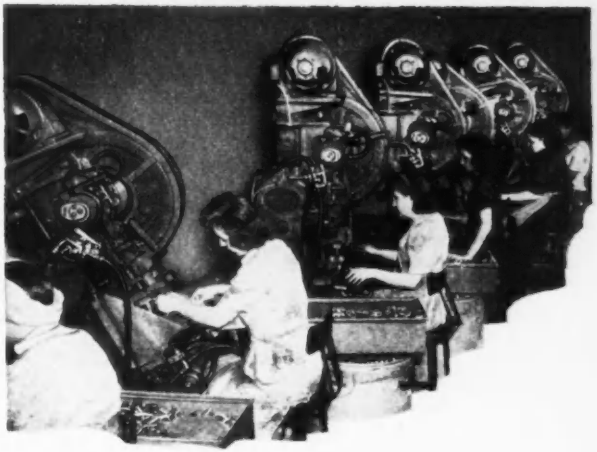

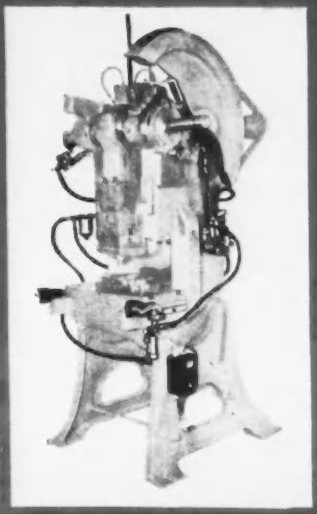

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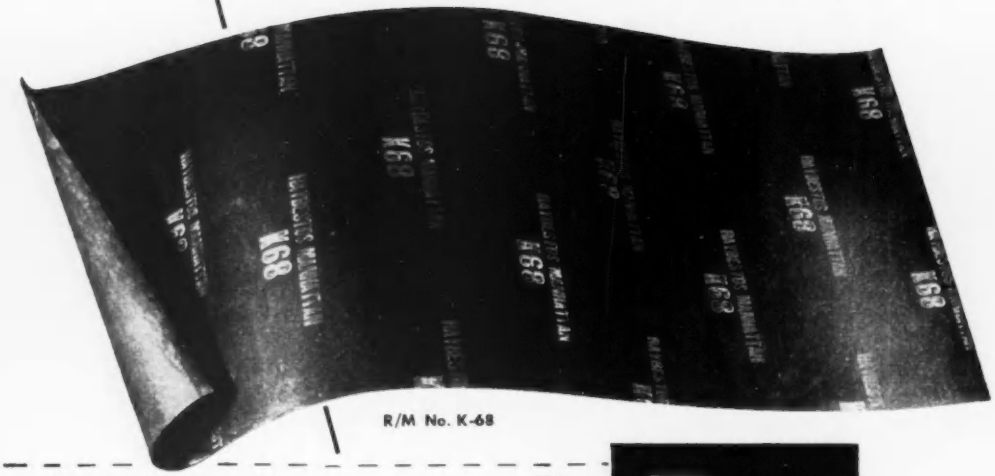

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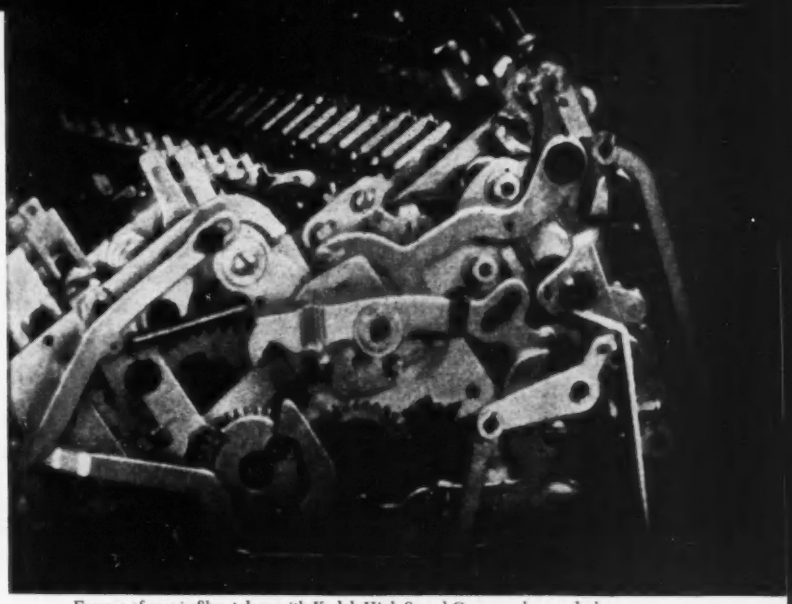

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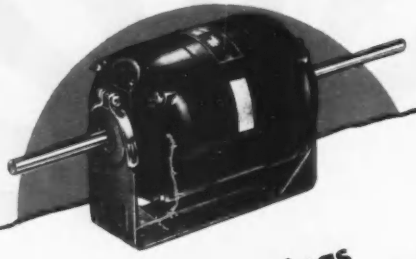

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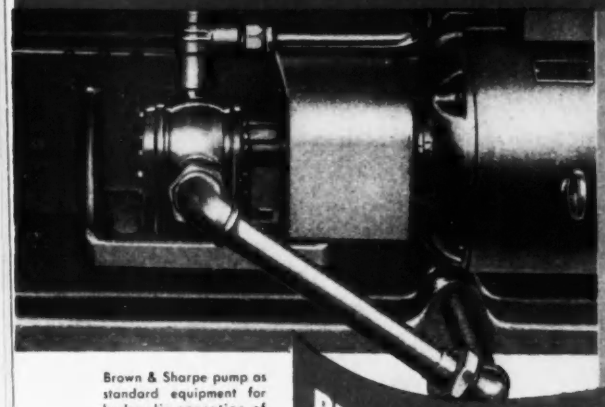

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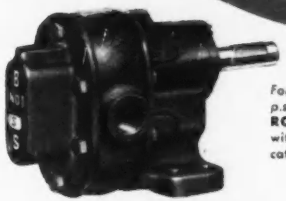

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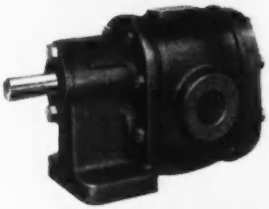

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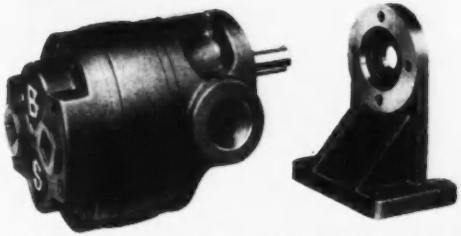

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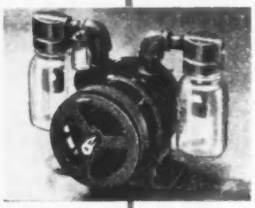

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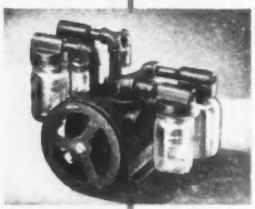
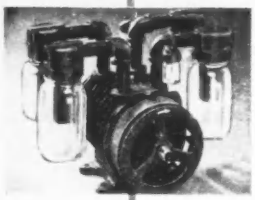


Model 10 x 1040, small DUAL CHAMBER PUMP—9 c.f.m. from each chamber. Vacuum to 20", pressure to 15 p.s.i.



Model 11 x 1740, large DUAL CHAMBER PUMP—14 c.f.m. (to 10 p.s.i.) from pressure chamber; 9 c.f.m. (to 15") from vacuum chamber.

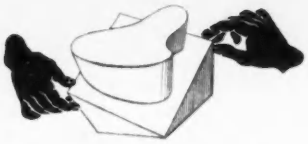
Look what these 3 new Air Pumps offer: They're designed to meet the specific needs of automatic feeding operations . . . handling paper, cardboard, thin metal, acetate, etc. They give *both* strong "blow" for separating—and large capacity low vacuum for "pick-up" of sheet materials.

With all the inherent advantages of Gast Rotary Design, they run quietly, producing large volume per horsepower at comparatively low speeds. They're trim in appearance and unusually compact. V-belt drives simplify installation and make speed control easy.

If you're building machines that can be fed with suction fingers—you'll want full details. Remember —"Air may be your Answer!"

WRITE FOR DETAILS ON 3 NEW AIR PUMPS—ALSO "APPLICATION IDEAS" BOOK

GAST ROTARY AIR MOTORS • COMPRESSORS • VACUUM PUMPS
(TO ONE H.P.) (TO 30 LBS.) (TO 28 INCHES)
GAST MANUFACTURING CORP., 139 Hinkley St., Benton Harbor, Mich



The shape's the thing...

The selection of a suitable steel and its subsequent satisfactory performance can be made easy by good design.

How and in what shape a part is made is, we hold, of fundamentally greater importance than of what it is made.

In designing a piece of machinery it is necessary to consider Design, the choice of steel, and its Heat Treatment. All three are highly significant factors, but of them we believe Design to be vital because even the best in steel and treatment will not save a poorly designed part.

To evaluate the importance of good design and its vital relationship to the selection of steel and its heat treatment, we have prepared a book—"Three Keys to Satisfaction". This starts by discussing mainly design factors involved in stress concentrations, and includes useful sketches comparing poor and good features of design from the aspect of subsequent metallurgy. It is available on request to all engineers and designers.

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Koppers New

CAMERA BLACK

POLYSTYRENE

solves four important problems

A manufacturer of cameras and photographic equipment was searching for one plastic that would solve four major problems. The plastic must have (1) complete opacity, (2) photochemical inertness, (3) higher heat distortion resistance than general-purpose polystyrene and (4) the cost must be low

Koppers Camera Black Polystyrene can be used for cameras, film holders, film cartridges, film cartridge winding machines, developing tanks, etc. Spools molded for Polaroid by Ontario Plastics, Rochester, N. Y.

KOPPERS Company went to work on these problems and developed a special polystyrene—CAMERA BLACK—which had all the desired characteristics.

It had complete opacity. Tested with supersensitive film in comparison with a ½-inch steel plate, the Koppers Camera Black showed equal opacity. The film was covered with a polystyrene sheet 1/16" thick, then half the film was covered with the steel plate and the entire covering exposed to a 500 watt lamp for 15 minutes. The developed film showed no difference between the two halves.

It had photochemical inertness. Camera Black Polystyrene showed no chemical reaction to the most sensitive film and to the chemicals used in the photographic processes.

It had high resistance to heat distortion. Koppers new Polystyrene has a minimum heat distortion temperature of 200°F. Products made from it do not distort under the heat of window displays or from being washed in scalding water.

The cost was low. Koppers Camera Black Opaque Polystyrene sells at the same low price of regular polystyrene in special colors. There is no added premium.

What is your problem in plastics?

Koppers maintains a staff of chemists, molding and material engineers and technical specialists who are ready to help you at any time. If you have a special problem, write and tell us about it.

Koppers Perfected Plastics include many formulations of Polystyrene, Cellulose Acetate and Ethyl Cellulose. These are available in transparent, translucent and opaque and in any desired color. Write for complete information.

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Chemical Division **Pittsburgh 19, Pa.**

Regional offices: New York, Boston, Chicago and San Francisco

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How to reduce
APPARATUS PORCELAIN COSTS

IF apparatus porcelain costs have you stymied . . . on products either existing or planned . . . bring your problem to Locke.

HERE, at your disposal, is one of the world's finest and largest Ceramic Research Laboratories, staffed by experts whose porcelain "know-how" is backed by Locke's more than 55 years experience with *all* phases of porcelain design and manufacture.

FREQUENTLY Locke, in combination with your engineering department, can effect major cost reductions in apparatus porcelain by re-designing a piece so that it lends itself to modern low-cost manufacturing techniques.

SO, if you've got a problem in porcelain . . . either of a design or manufacturing nature . . . simple or complex, try us. The recommendations of our Ceramic Engineers may enable you to produce an existing piece for considerably less . . . or a new piece for much less than you expected to pay.

CONSULT your local Locke representative, or write direct. Address Department AP.

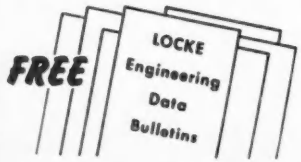
HOW PROPER HOOD DESIGN REDUCES PORCELAIN COSTS

Designs often specify deeply undercut hoods which require several costly manufacturing operations. Yet, in many cases, shallow hoods can be simply and inexpensively produced without jeopardizing mechanical or electrical performance. In most cases, Locke engineers recommend a minimum spacing between hoods of 3 to 4 times the undercut depth.

Costly hood design

Less costly hood design

Perhaps such money-saving details can be incorporated in your designs. Why not call on us and find out.



Contain plenty of money-saving hints on the design and manufacture of apparatus porcelain. Write for your free copy—today.

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HEAT DISSIPATION
No longer a Problem!

X-Ray Corporation of America standard x-ray showing the Eastern Model 2-XR Heat Transfer Unit in operating position.

Eastern Model 2-XR Heat Transfer Units successfully dissipate the heat generated by x-ray tubes in standard X-Ray machines built by the X-Ray Manufacturing Corporation of America, New York City. This insures uniform temperature control and longer tube life. The unit eliminates the inconvenience and expense of using tap water as the tube cooling system.

If you have a problem that can be solved by using equipment that contains a pump as an integral unit, why not consult Eastern engineers?

Eastern pumps require no introduction. Their compact design and remarkable performance make them ideally adaptable where space and portability are factors.

They incorporate the finest of workmanship and material. Consultations on special pump problems entail no obligation. Write:

Eastern Model D-11 heavy duty centrifugal pump. Size: 10" x 5½" x 5". Weight: 18 lbs. Power 1/8 h.p. heavy duty induction motor. Available in 110 or 220 volts a.c. Maximum output 8 g.p.m. at zero pressure. Maximum pressure 14.5 lbs. p.s.i. at shut off.

Eastern
INDUSTRIES, INC.
296 Elm Street
Dept. 290, New Haven, 6, Connecticut

"I didn't know you people made_____!"

Fill in to suit

We have been in business now for 58 years and yet quite often some good customer of our says — "Why, I didn't know you people made friction clutches!" Or the exclamation might cover skip hoist drives, car pullers, door hoists or any one of many other Jones products.

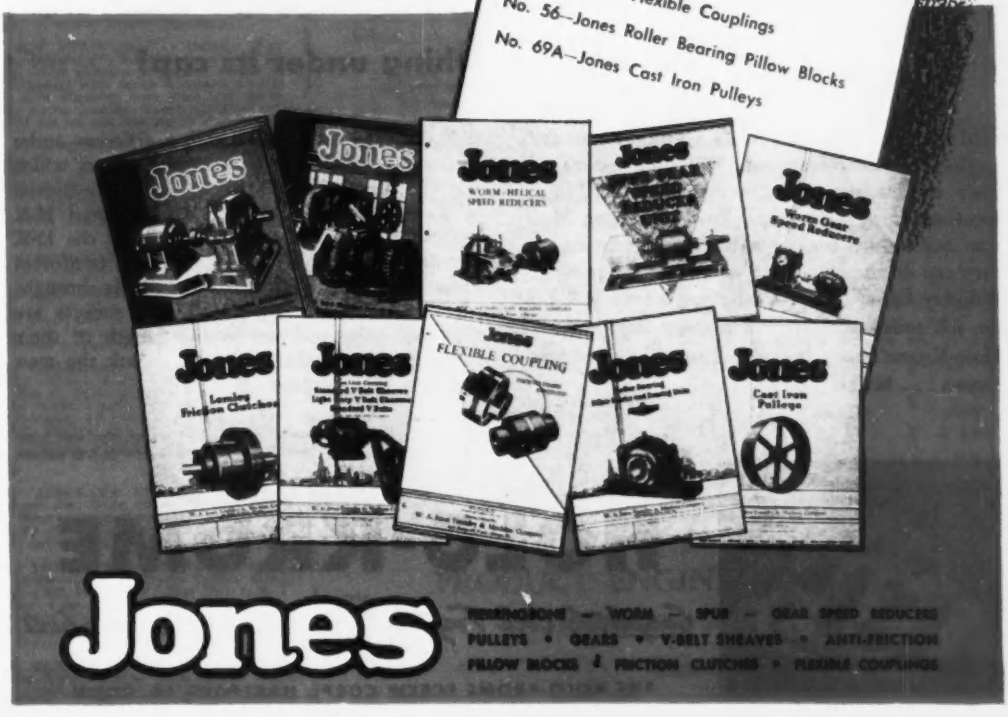
In dealing with our suppliers we often find ourselves in the same position. We establish certain buying habits and it sometimes comes as a shock to find that a firm right around the corner may have just the services or the products we need.

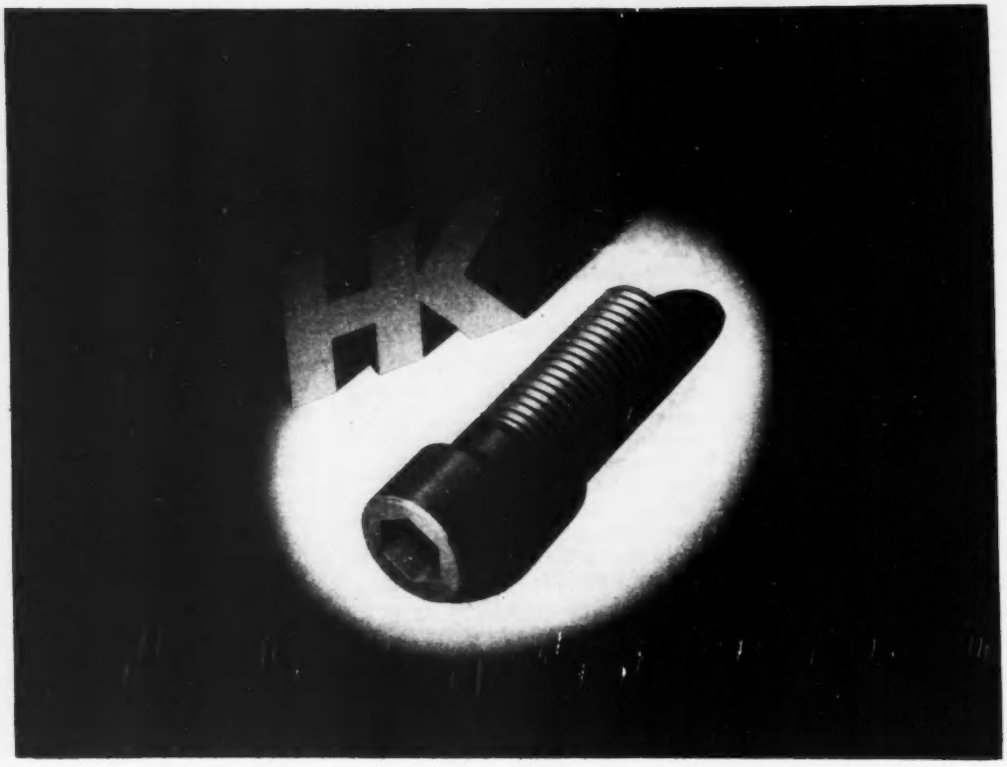
We therefore present the group of catalogs shown below with the thought that some one of them may help you solve some problem that has just come up.

W. A. JONES FOUNDRY & MACHINE CO.
4417 Roosevelt Rd., Chicago 24, Ill.

Any, or all of these Jones Catalogs sent on request

No. 70—Jones Herringbone Speed Reducers
No. 71—Jones Cut Gears
No. 75—Jones Worm Helical Speed Reducers
No. 55—Jones Spur Gear Speed Reducer Units
No. 68—Jones Worm Gear Speed Reducers
No. 60—Jones Friction Clutches
No. 588—Jones V-Belt Sheaves
No. 78—Jones Flexible Couplings
No. 56—Jones Roller Bearing Pillow Blocks
No. 69A—Jones Cast Iron Pulleys



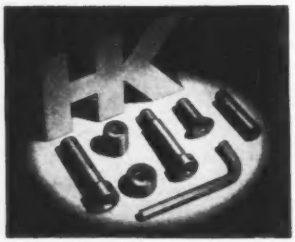


. . . the screw with something under its cap!

Holo-Krome Socket Head Cap Screws are engineered with foresight. The very nature of their use requires that they be tightened and loosened many times over. For this reason H-K Cap Screws are packed with reserve stamina so they can do the future job as well as the present. Industry knows that Holo-Krome screws will do the job today, tomorrow and every day, because Holo-Krome's only business is to make the finest screws . . . better.

H-K Cap Screws have something *different* under their cap . . . continuous, unbroken fibres which run the length of the screw. This is achieved by Completely Cold Forging, a patented H-K process. It compacts the core fibres of the H-K *Hetraspan** Steel into a contour which reinforces socket walls and distributes stress evenly throughout the head, with the result that sockets are micrometrically accurate to full length of their useful depth. STAMINA? . . . . . ask the men who use Holo-Krome.

*a special analysis heat treated alloy steel scientifically held to exacting Holo-Krome specifications.



HOLO-KROME

Completely Cold Forged GUARANTEED ... *Socket Screw Products*

THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN.

NEW CATALOGS AND BULLETINS

A Reader Service To Help Keep Your Library Up-to-Date

(1) STAMPINGS AND MOLDINGS—Aluminum Goods Mfg. Co., Manitowoc, Wis. Booklet, 52 pp. Photos show plant, facilities and typical products of company, which produces contract stampings and moldings of component parts for other manufacturers. Booklet features new, expanded facilities and technical services.

(2) THREAD-CUTTING SCREWS — Shakeproof, Inc., Div. of Illinois Tool Works, 2501 N. Keeler Ave., Chicago 39, Ill. Bulletin, 12 pp. Illustrates a line of self-tapping machine screws available in eight head styles with screw sizes ranging from 4-40 to 5/16-18, for use with sheet steel, cast iron, and sheet aluminum. Also features eight other fastening devices.

(3) MAGNETIC SEPARATORS — Eriez Mfg. Co., 960 E. 12th St., Erie, Pa. Catalog 14, 12 pp. Describes line of permanent non-electric megntic separators for tramp iron removal and electronic metal detectors. Specifications, including weights, sizes, and strength comparisons given.

(4) METAL STAMPINGS—Dayton Rogers Mfg. Co., 2824 13th Ave., S., Minneapolis 7, Minn. Bulletin, 8 pp. Drawings and pictures show some of the products produced by company. They do contract stamping of a wide variety of metals in small lots. Prices are also given.

(5) FHP MOTORS—Electric Motor Corp., Racine, Wis. Catalog, 4 pp. Illustrations and specifications given for 13 types of fhp motors and six types of small gear reduction units, including both single and double reduction models with ratios as high as 2,700 to 1, and as low as 3 to 1. Both a-c and d-c motors are available.

(6) V-BELT DRIVES—T. B. Wood's Sons Co., Chambersburg, Pa. Catalog 192, 96 pp. Contains complete specifications and engineering data on stock drives, special drives, sheaves and V-belts. Also has a section of related engineering data.

(7) AIR CYLINDERS — Gerotor May Corp., Baltimore 3, Md. Catalog Section 54, 12 pp. Gives pictures and specifications of air cylinders with seven standard mountings, nine diameter bore sizes and up to 96 in. stroke lengths. These cylinders are for 150 psi air and 300 psi oil service.

(8) PIPE INSULATION—Owens-Illinois Glass Co., Kaylo Div., Toledo 1, Ohio. Bulletin, 4 pp. Contains information for specifying and using this calcium silicate insulating material, which is effective from 200 to 1,200 F. Also, tabulated data on pipe sizes, heat losses and other pertinent subjects.

(9) ELECTRICAL INSTRUMENTS—The Simpson Electric Co., 5200-18 W. Kinzie St., Chicago 44, Ill. Catalog 16, 50 pp. Gives specifications, dimensional diagrams, uses and price list of portable test equipment, panel and switchboard instruments, laboratory instruments, and related equipment and accessories.

(10) HYDRAULIC PUMPS AND MOTORS—Cannon & Co., 2310 E. 8th St., Los Angeles 21, Calif. Bulletin, 6 pp. Cutaway photo shows construction of the positive displacement oil hydraulic unit, which is equally efficient as a pump or fluid motor for operating pressures up to 3,000 psi. Unit comes in both flange and base mountings.

(11) AIRCRAFT SWIVEL JOINTS — Chiksan Co., Brea, Calif. Catalog 1A, 8 pp. Shows pictures and dimensions of a variety of swivel joints designed for aircraft installation.

(12) LOW TEMPERATURE MELTING ALLOYS—Cerro de Pasco Copper Corp., Dept. CAC, 40 Wall St., New York 5, N. Y. Folder, 4 pp. Lists all the known applications and uses for these low temperature melting alloys. Gives physical properties of alloys.

(13) CARBON-GRAPHITE MATERIALS —The United States Graphite Co., Saginaw, Mich. Catalog G-49, 64 pp. This catalog gives complete data on 35 grades of Graphitar, which is an extremely hard, light material for bearings and seals. Design principles, uses, and operating information given.

(14) PRECISION VALVES AND FITTINGS—Kohler Co., Kohler, Wis. Catalog, 20 pp. Describes and specifies such precision parts as check valves, jet engine controls, drain valves, injection nozzles, engine primers, plug valves and a wide variety of flared tube, bulkhead, pipe thread, and hose nipple fittings.

(15) EXTRUDED ALUMINUM SHAPES —Reynolds Metals Co., 2500 S. Third St., Louisville, Ky. Bulletin, 4 pp. Explains the design applications of extruded aluminum shapes and includes ordering data, tables on alloys and tempers and nominal chemical compositions.

(16) ROLLER CHAINS AND SPROCKETS—Diamond Chain Co., Inc., Indianapolis 7, Ind. Catalog 709, 42 pp. Presents complete dimension and price list of single and multiple strand roller chains and chain sprockets. Hp ratings, lubrication directions, and length calculations also included.

(17) LEATHER PACKINGS — C. W. Marsh Co., Muskegon, Mich. Bulletin, 6 pp. Drawings and photos show uses of Thermo Vee Packings. Shows how to determine packing height and other design details.

(18) INDUSTRIAL AUTOMATIC CONTROL DEVICES—Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa. Bulletin 103, 6 pp. Describes a line of diaphragm motors, control valves, butterfly valves, regulators, pressure tranamitters, and other pneumatic devices.

(19) VIBRATION DAMPERS — Korfund Co., Inc., 48-19-G, Thirty-Second Place, Long Island City 1, N. Y. Several types of cork and rubber mountings for vibration control which require no bolting or cementing are described with typical installations shown.

(20) INDUSTRIAL ELECTRONIC TUBES—General Electric Co., Electronics Dept., Schenectady, N. Y. Supplement 10, Industrial Tube Manual, 64 pp. Presents seven types of new industrial tubes with graphs to show full operating characteristics of each.

(21) ALUMINUM PIPE FITTINGS—Reynolds Metals Co., 2500 S. Third St., Louis-

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ville 1, Ky. Bulletin, 4 pp. Presents a new line of fittings which require no pipe threading or welding. Three basic units produce 14 different piping arrangements. Sizes and weights are listed.

(22) STEEL CASTINGS—Steel Founders' Society of America, 920 Midland Bldg., Cleveland 15, Ohio. Booklet, 36 pp. Design details are given to prove the advantages of steel castings. A comprehensive folder tabulates the general engineering types of steel castings according to tensile strengths.

(23) GEAR MOTORS—Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill. Catalog 1815-A, 12 pp. Shows how to select gear motors, and gives sizes, hp ratings and other specifications of gear motors.

(24) CENTRIFUGAL SWITCHES—The Euclid Electric & Mfg. Co., Madison, Ohio. Bulletin 1001, 4 pp. Photos show construction and sequence of operation of switch. A description of several models, and the applications of each are given.

(25) CORROSION RESISTANCE OF CASTINGS—The Cooper Alloy Foundry Co., Hillside, N. J. Folder, 4 pp. Complete information is tabulated on the effects of acids, salts, gases, alkalies, and other corrosive media on stainless steel, monel, and nickel castings.

(26) SANITARY PUMPS—The Yale & Towne Mfg. Co., Stamford, Conn. Catalog, 12 pp. Pictures and descriptions of four models of nickel alloy sanitary pumps which handle up to 40 gpm at 375 rpm. Price and weight list given. Operating characteristics graphically shown.

(27) LOW FREQUENCY OSCILLOSCOPES—Smith & Stone Limited, Special Products Div., Georgetown, Ontario. Bulletin, 8 pp. Gives description and uses for a new low frequency cathode-ray oscilloscope with optional recording camera, which is for measurement in the subaudible frequency range. Instrument has adequate high frequency response to allow use in fields of vibration study, strain-gage measurement, and servo-mechanism development.

(28) VACUUM PUMPS AND ACCESSORIES—Central Scientific Co., 1700 Irving Park Road, Chicago 13, Ill. Bulletin 10 A, 48 pp. Gives description, pictures, uses, and price list of a great variety of high vacuum apparatus, most of it for laboratory use.

(29) STAINLESS STEEL TUBING—J. Bishop & Co., Platinum Works, Malvern, Pa. Bulletin, 8 pp. Gives sizes, uses, and other specifications of cold-drawn stainless steel tubing from 0.008 to 1 in. in dia. Tubing is for mechanical, capillary and hypodermic uses.

(30) RELAYS—American Relay & Controls, Inc., 4900 W. Flournoy St., Chicago 44, Ill. Bulletin, 4 pp. Shows pictures, uses, and complete specifications of 12 types of a-c and d-c relays.

(31) ELECTRIC CONTROL DEVICES—Ward Leonard Electric Co., Mount Vernon, N. Y. Bulletin 100,000; 8 pp. Describes, pictures, and specifies rheostats, resistors, relays, motor starters, contactors, control accessories, and dimmers.

(32) FORGED STEEL CASTERS—The Hamilton Caster & Mfg. Co., 1611 Dixie Highway, Hamilton, Ohio. Bulletin 60, 12 pp. Announces a new line of drop-forged steel casters made in regular, heavy, and extra heavy duty models. Semi-steel, molded plastic, or rubber wheels are furnished in all models. There is a 4 to 10 in. wheel diameter range.

(33) LOCKNUTS — Security Locknut Corp., 1815 N. Long Ave., Chicago 39, Ill. Bulletin, 4 pp. Shows construction of a new locknut which uses an elliptical steel retaining ring together with a standard nut for its locking action. Tables of U.S. and S.A.E. threads sizes are also given.

(34) DIAPHRAGM VALVES—Crane Co., 836 S. Michigan Ave., Chicago 5, Ill. Bulletin, 8 pp. Explains the diaphragm (or packless) valve principle, gives recommendations for use, and describes materials and construction of valves, which have a working pressure of 150 lb with air, water, or gas at temperatures up to 180 F. Sizes range from ¼ to 4 in. with 4 types of the valve. Price list is included.

(35) AUTOMOTIVE CHAIN DRIVES—Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill. Booklet 2065, 36 pp. Gives applications, dimensions, and complete engineering data for both automotive timing chain and industrial engine chain. Diagrams show a variety of chain drive arrangements.

(36) GAS COMBUSTION EQUIPMENT—Bryant Heater Co., Industrial Div., 1020 London Rd., Cleveland 10, Ohio. Catalog ID-292, 12 pp. Presents a line of gas burning component parts and accessories, including gas-air mixers, blowers and boosters, several types of burners, pilot and ignition devices, and controls, valves and regulators.

(37) SERVOMECHANISM COMPONENTS—Reeves Instrument Corp., 215 E. 91st St., New York 28, N. Y. Catalog, 32 pp. Shows the technique of using a "bread board' in the building of any model mechanism. Illustrates a completed "bread board" and gives complete details of each of the component parts, which include gears, shafting, couplings, component hangers and shaft hangers, clamps, differential gear units, magnetic clutches, functional potentiometers, servo motors, and many other such devices.

(38) ROTARY PUMPS — Worthington Pump and Machinery Corp., Harrison, N. J. Bulletin W-484-B1, 8 pp. Presents dimensions and specifications for small capacity general service rotary pumps for machine tools, metering units, gear reducers, hydraulic operation, etc. Capacities range from 4 to 51, from 2.4 to 22, and from 1.6 to 22 gpm at 1,750, 1,150, and 850 rpm, respectively for viscosities up to 400 SSU. Higher viscosities are possible.

(39) SOCKET SCREWS — The Holo-Krome Screw Corp., Hartford 10, Conn. Catalog 49, 24 pp. Lists prices and dimensions for line of completely cold forged cap screws, set screws, stripper bolts, flat and round head cap screws, pipe plugs, key sets, and dowel pins. Prices are given for special as well as standard sizes in all units.

(40) FREQUENCY METERS—James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa. Bulletin 32, 20 pp. "Frahm" resonant reed frequency meters are pictured and explained, with applications and specifications given. Meters are made in three general types: miniature, switchboard, and portable. Special instruments are also supplied.

(41) POWDERED METAL ELECTRICAL CONTACTS—Fansteel Metallurgical Corp., North Chicago, Ill. Bulletin 7.101, 12 pp. Presents line of light and heavy-duty electrical contacts classified under two main groups: those made of silver plus a refractory metal, and those having copper plus a refractory. Physical properties, design features, and applications given.

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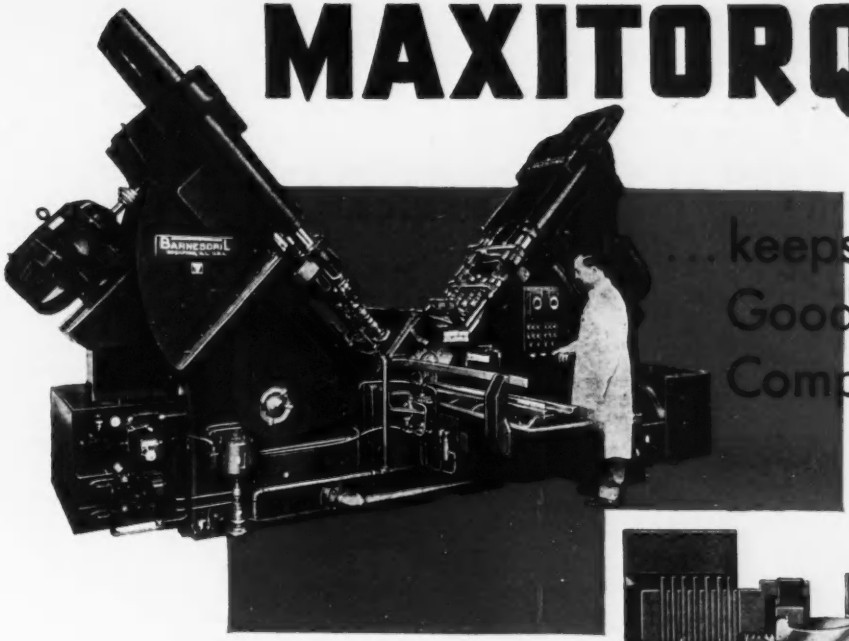

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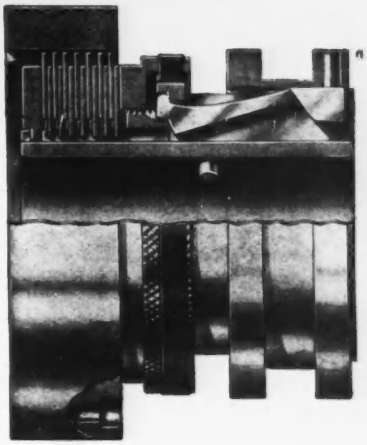

Today we express our appreciation to Barnes Drill Co., Rockford, Illinois, for *their* appreciation of our Maxitorq Clutch . . . selected as original equipment on the Barnesdril 320 Honing machines.

In each head a double Maxitorq is used . . . one side for engaging the spindle, the other side as a brake to stop spindle rotation.

Machine and Product designers will discover in Maxitorq the design and quality features that are so successfully controlling power transmission on nationally known Machine Tools, Textile, Packaging, Labeling, Printing, Mining and other machinery . . . and for a diversity of products like Lift Trucks, Cranes, Mowers, Polishers, Saw Mills, etc.

Maxitorq Clutches are shipped completely assembled, ready to slip onto a shaft . . . no tools required for adjustment, take-apart or assembly. Discs ride free in neutral, preventing drag, abrasion, heating. Capacities to 15 H.P. at 100 r.p.m., single or double, wet or dry.

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FLASH-BUTT WELDED RINGS & BANDS

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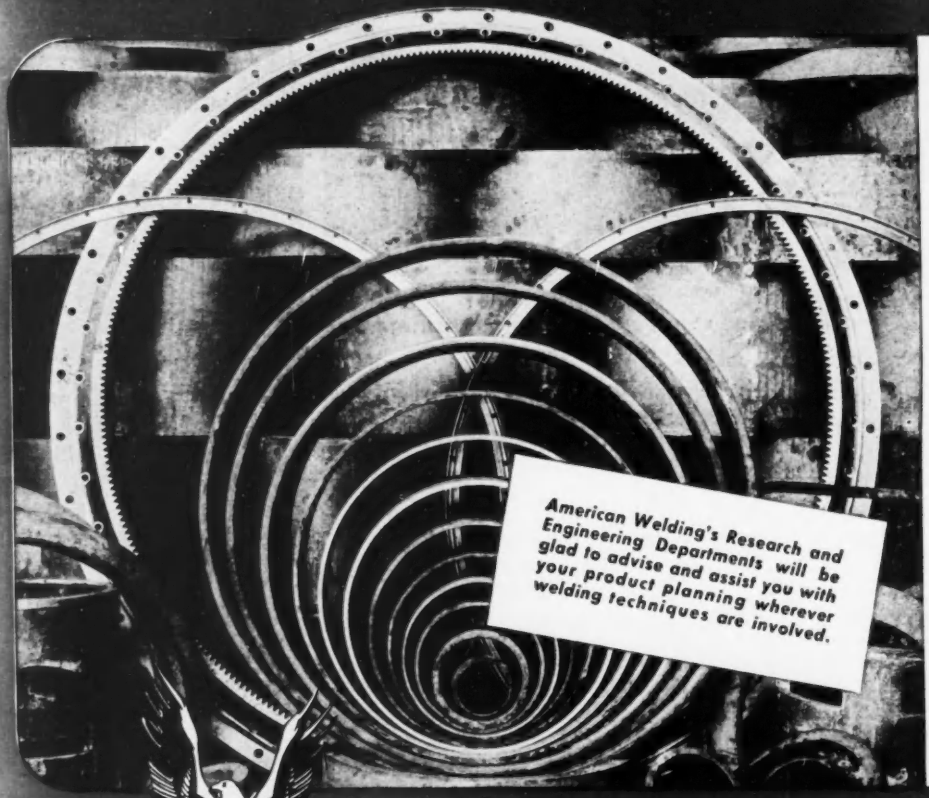
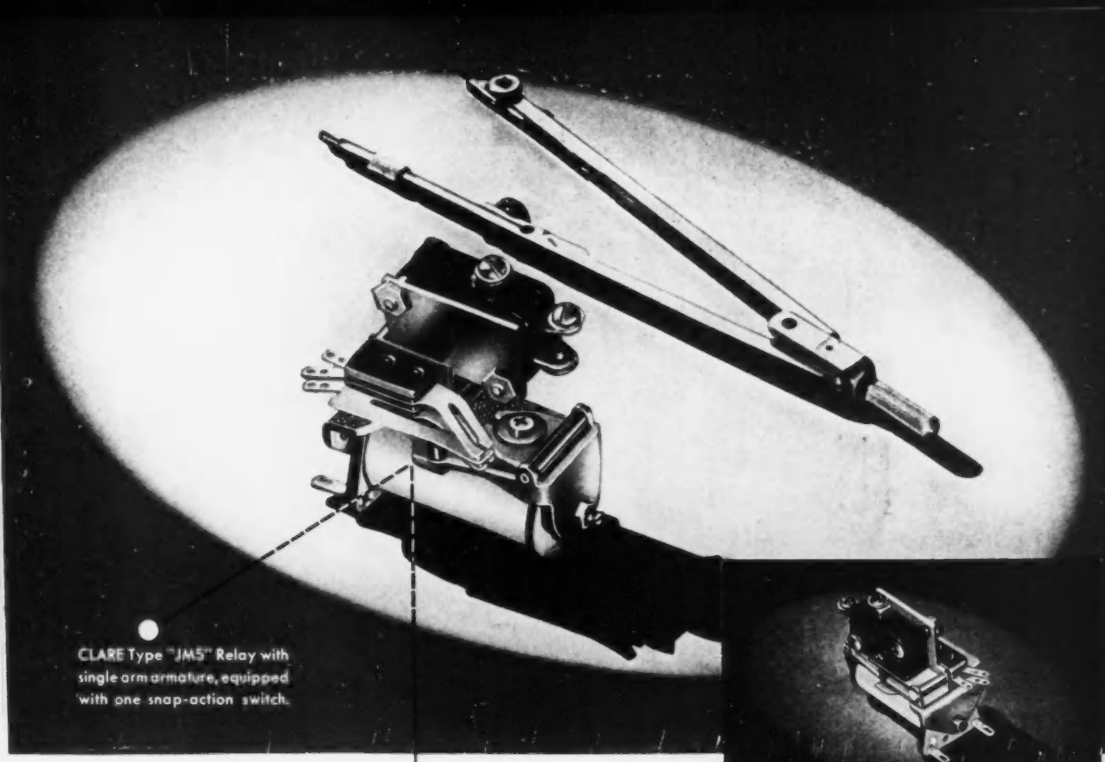


American Welding's Research and Engineering Departments will be glad to advise and assist you with your product planning wherever welding techniques are involved.

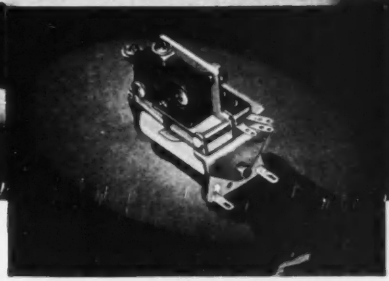
Send for 16-page illustrated catalog.

THE AW AMERICAN WELDING AND MANUFACTURING COMPANY

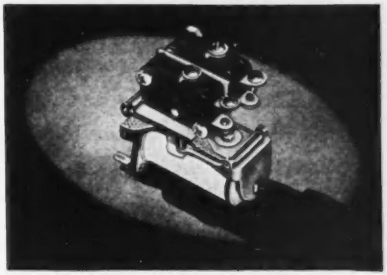
140 BIETZ ROAD • WARREN, OHIO



CLARE Type "JMS" Relay with single arm armature, equipped with one snap-action switch.



Showing mounting of snap-action switch on CLARE Type "JMS" Relay with single armature.



CLARE Type "JMS" Relay provided with double armature and two snap-action switches.

THIS SMALL, COMPACT CLARE RELAY

WILL SWITCH 1250 WATTS WITH AN INPUT OF 1 WATT!

This new CLARE Type "JMS" Relay is a sensitive relay for switching heavy a-c loads with small d-c controlling currents . . . as high as 1250 watts can be switched with a 1-watt input.

It combines the outstanding features of the larger CLARE Type "CMS" Relay with the small size and light weight of the CLARE Type "J" Relay and employs a new-type Micro precision switch of unusual efficiency and compact design.

The CLARE Type "JMS" Relay is especially suitable to locations subject to sudden jolts, constant vibration or tilting. It may be provided with either one or two Micro snap-action switches, or with one switch and a pileup of twin-contact springs. For installations where quick removal or replacement may be desirable, it may be fitted and wired to a standard radio type plug.

This new relay is a development of CLARE's unceasing effort to keep pace with every industrial relay requirement. Our engineers and sales representatives are constantly at your service to provide just the relay to meet your specific need.

For full information on the CLARE Type "JMS" Relay, look up the CLARE office in your classified telephone directory . . . or write for Bulletin 102 to C. P. Clare, 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address CLARELAY.

STANDARD SPECIFICATIONS

Contacts: Snap-action, enclosed. Varying capacity: 10 amperes at 125 volts; 5 amperes at 250 volts.

Residual: Lock Screw (Adjustable).

Mounting: May be mounted on relay bases or strips as well as mounting bars or individual mounting brackets.

Dimensions: Overall length: 2¼"; width: 1⅛"; height: 2".

Weight: Net: 4 oz. (approx.); Shipping: ½ lb. (approx.)

Write for Clare BULLETIN 102

CLARE RELAYS

First in the Industrial Field

Partial Shipments Only...

Every shipment that leaves the Twin Disc Factory is incomplete . . . only because the *service* that goes with each sale is delivered later . . . whenever and wherever it may be needed.

Twin Disc maintains five factory branches and 47 Parts Stations, strategically located throughout the country, to provide speedy and efficient service.

It is this policy of complete follow-up service that has given Twin Disc products the broad acceptance they enjoy among leading equipment manufacturers. Specify Twin Disc on your next power application.

TWIN DISC CLUTCH COMPANY
Racine, Wisconsin
(Hydraulic Division, Rockford, Illinois)

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

YOU SAVE up to 30%

YOU DON'T PAY FOR SCRAP LOSS OR "REJECTS" WHEN

Reynolds

MAKES ALUMINUM PARTS TO YOUR SPECIFICATIONS

NO SORTING OR SCRAP HANDLING

NO SHIPPING OR SUPPLY PROBLEMS

NO LABOR OR MACHINERY PROBLEMS

Scrap and rejects require handling and shipping that sacrifice profits. When you use Reynolds production facilities, this scrap and reject metal goes back into remelt at the source... you never bother with it, you pay no handling charge.

Here is a complete aluminum service from mine to finished products. You specify quantity and delivery. Reynolds delivers inspected parts or complete assemblies. You get all of the advantages of mass production without the worry of factory space, machine and manpower requirements. And you can count on a fixed cost. That's why Reynolds is delivering more and more parts and assemblies to some of the nation's largest manufacturers.

For the complete story of advantages, send for booklet explaining this unique service. Return the coupon below or call the Reynolds Sales Office listed under "Aluminum" in your classified telephone directory. Reynolds Metals Company, Industrial Parts Division, Louisville 1, Ky.

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INDUSTRIAL PARTS DIVISION

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A complete aluminum fabrication service including blanking • embossing • stamping • drawing • spinning • forming • roll shaping • assembling and finishing •

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2050 South Ninth Street, Louisville 1, Kentucky
Send the new folder on Aluminum Parts and Assemblies.

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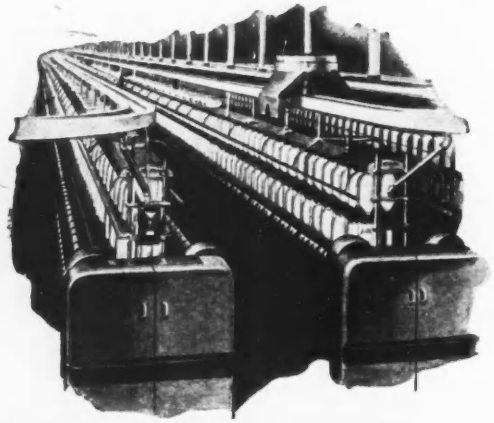
REYNOLDS PIONEERING MADE ALUMINUM COMPETITIVE...*TAKE ADVANTAGE OF IT!*

Lower costs and increased operating efficiency result when equipment is made appreciably lighter with Dow

MAGNESIUM

the world's lightest structural metal!



And this is true of many, many different kinds of machines. If you are trying to cut excess pounds off parts that go into your equipment, there's one material that stands head and shoulders above all the others for that job. It's magnesium, the world's lightest structural metal.

Magnesium is 33⅓% lighter than aluminum, its closest rival—75% lighter than steel. Yet for all its lightness, magnesium is a thoroughly sound material and is easily worked by conventional shop methods.

Designers and manufacturers of textile equipment, for example, know the importance of keeping dead weight down to an absolute minimum. They've seen how magnesium pays by making reciprocating parts appreciably lighter—and how lighter parts increase operating speed, lower down-time and reduce power requirements. Magnesium can pay for you, too. Write for your free copy of "How Magnesium Pays".

MAGNESIUM DIVISION
THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN
New York • Boston • Philadelphia • Washington • Cleveland
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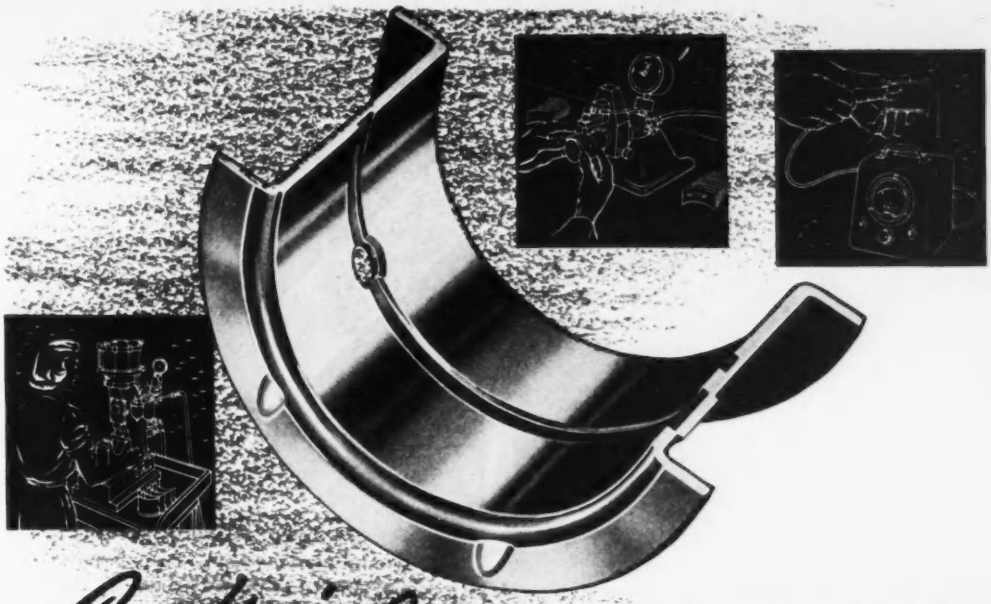
Dow Chemical of Canada, Limited, Toronto, Canada

Cut dead weight—increase machine speeds with Magnesium

Magnesium is the obvious metal for high speed rotating and reciprocating machine parts. Magnesium is light, yet remarkably strong and durable. And magnesium is available in all common forms—from sand castings and die castings to an almost unlimited variety of extruded shapes—to simplify design, speed fabrication and lower costs.

Lighter Products Sell—make your product Magnesium Light!



Combining PRODUCTION IN THE MILLIONS WITH QUALITY IN THE INDIVIDUAL BEARING

To assure top quality in mass production of sleeve bearings, at low cost, our Quality Control and Production Methods organization conducts as many as 108 separate tests for material quality and physical accuracy of the individual bearing. Specialists for almost 50 years, our six-plant organization is tailored to the peculiar needs of sleeve bearing production—from original research to field tests of the finished product. Our engineering department will gladly consult with you on your problems.

28 PRECISE MACHINE OPERATIONS

84 MEASUREMENT CHECKS

24 ADDITIONAL TESTS

are conducted on a strip-type, copper-lead lined, steel-backed flanged bearing.

HIGH SPEED, high temperature, automotive type bearings available in many combinations.

SPEED & LOAD bearings for pumps, compressors, industrial electric motors and similar uses.

HEAVY LOAD for big Diesels, power plants, etc.—bearings up to 27½" O.D., steel and bronze back.

BRONZE PARTS in many shapes, sizes; thrust washers, bushings; for many types of applications.

Power goes to work smoothly through

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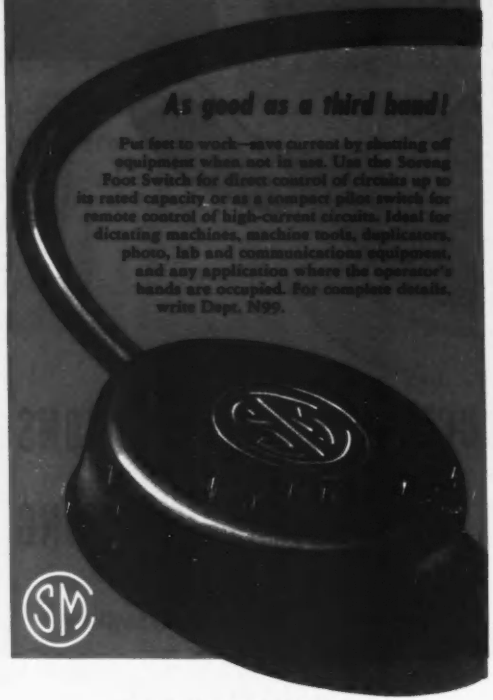
FEDERAL Mogul Silent SLEEVE BEARINGS

11043 SHOEMAKER, DETROIT 13, MICH.

SORENG FOOT SWITCH



As good as a third hand!

Put foot to work—save current by shutting off equipment when not in use. Use the Soreng Foot Switch for direct control of circuits up to its rated capacity or as a compact pilot switch for remote control of high-current circuits. Ideal for dictating machines, machine tools, duplicators, photo, lab and communications equipment, and any application where the operator's hands are occupied. For complete details, write Dept. N99.

SPECIFICATIONS

- Rugged construction. Strong steel case will support operator's full weight without damage to switch.
- Rating: 6 amperes at 125 volts A.C.; 3 amperes at 250 volts A.C. (inductive load).
- Positive snap-action switch and large-area silver contacts assure dependability and long life.
- Operates with light foot pressure on any part of case. No dead spots.
- Case covered with dust-proof, skid-proof, splash-resistant rubber boot.
- Regularly furnished single pole, single throw. Your choice of normally open or normally closed types.
- Also available in single pole, double throw.
- Compact size—3½" dia. x 1" thick.

SORENG MANUFACTURING CORPORATION

Main Plant—1901 Clybourn Ave. • Chicago 14
Branch Plant—231 Stone St. • Fremont, Ohio

Quantity
PRODUCTION
of
GREY IRON CASTINGS

ONE OF THE NATION'S LARGEST AND MOST MODERN PRODUCTION FOUNDRIES

ESTABLISHED 1866
THE WHELAND COMPANY
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AN ALL TIME RECORD FOR AN ALL STAR TEAM!

40.2% of All Carburetor Type Engines Built in 1947, 2 to 30 hp. Were WISCONSIN Heavy-Duty Air-Cooled ENGINES!

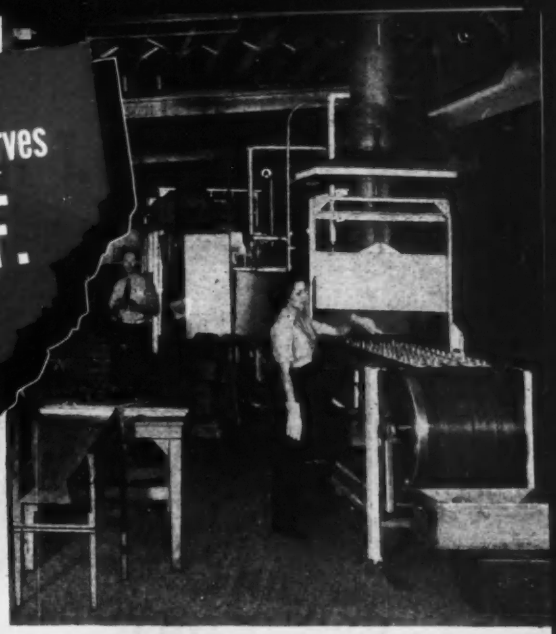
And here's the ALL STAR lineup . . . released in an official bulletin of the Bureau of Census, U. S. Dept., of Commerce, April 22, 1949.

In 1947, Wisconsin Motors built 51.7% of the engines in the 2 to 5 hp. range . . . in the 5 to 9 hp. range, 36.4% . . . 71.6% in the 15 to 22 hp. range . . . and in the 25 to 40 hp. range, 14.7%. Averaged together, 40.2% of the engines in the 2 to 30 hp. range were Wisconsins — excluding automotive, aircraft and outboard marine engines, and engines for use as original equipment by various manufacturers.

These figures sum up the confidence of equipment builders and users who are the final judges in choosing superior engines *where it counts most* . . . on the job delivering the goods.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46 WISCONSIN

Record-breaking NICHROME* V Belt serves 7,000 hours at 2050°F. in Copper Brazing Furnace!



Delivery end of electric copper brazing furnace operated by National Stamping Company—brazed steel parts being delivered by continuous-mesh Nichrome V Belt.

BELT SPECIFICATIONS
length: 98' 6"
width: 20"
mesh: 3/8"
wire: 12 gauge Nichrome V

. . . actual life of this belt extended for many thousand hours more (a large percentage of the time at steel annealing temperature of 1840°F.), but its long service at 2050°F. makes its performance outstanding . . . in fact, puts this belt "at the head of the class."

For though wire belts may last, according to an internationally recognized furnace manufacturer, "practically forever" at lower temperatures such as 1300°—1400°F.—often employed for considerable periods in furnaces of this type—their useful lives are measured by service rendered under heat at 2050°F.

ALL KNOWN RECORDS BROKEN

Says Ashworth Bros., Inc., maker of the belt: "This Nichrome V wire belt was installed in a modern electric copper brazing furnace and operated at the Detroit plant of National Stamping Company from June 1, 1947 to September 24, 1948. Its history, including approximately 7,000 hours at 2050°F. under full load, indicates ***it broke all records for this type of service.***"

MORE OUTSTANDING FACTS

Further information only emphasizes the noteworthy performance of this veteran piece of furnace equipment. For example:

(a) Belt Size—belts of this size, 98' 6" long x 20" wide, must be exceptionally stable to give such long and efficient service.

(b) Production—approximately 380 lbs. of work were handled per hour.

YOUR HEAT-TREATING PROBLEMS AND DRIVER-HARRIS

In selecting *your* heat-treating equipment, remember the outstanding ability of Nichrome V to give top-level performance at high temperatures, such as that of copper brazing. And remember, too, that Driver-Harris has been engaged in finding the correct answers to furnace problems for more than 35 years. Our accumulated experience and unique specialized knowledge will help you to lower operating costs, reduce maintenance, minimize repairs, increase production.

Feed end of furnace—parts being placed on Nichrome V belt
(This belt supplied by Ashworth Bros., Inc., Worcester, Mass.)

50TH YEAR — SPECIAL PURPOSE ALLOYS SINCE 1899 — DH — 1899 - 1949

Nichrome is manufactured only by

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Seattle

*T.M. Reg. U.S. Pat. Off.

Use this catalog to help bring your products up-to-date with the HONEYWELL MERCURY Switch

This catalog has just been revised, to include the latest developments in the success story of Honeywell Mercury Switches. It's brief, to the point . . . tells the story without wading through reams of pages.

But, it contains all of the information you'll need at your finger tips . . . including leads, terminals and mounting clips. Send for Catalog 1343, today . . . and use it to specify Honeywell Mercury Switches in your next design job. They'll help you bring your products up-to-date!

MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
4459 Wayne Ave., Philadelphia 44, Pa.
Offices in principal cities of the United States, Canada and throughout the world

WHEN YOU WANT
- POSITIVE CONTACT
- EASE OF ACTUATION
- LONGER LIFE
- WIDE SELECTION

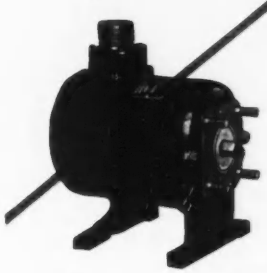
SPECIFY THE HONEYWELL MERCURY Switch

MINNEAPOLIS Honeywell — *Mercury Switches* FOR POSITIVE ACTION — BROWN INSTRUMENTS

Designing For Leadership..

WITH

Lamb Electric MOTORS



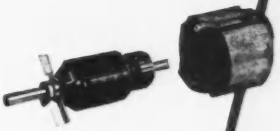
Intermittent high torque motor with low weight factor is adaptable to many general applications.

Knowing the importance of efficient, dependable motor operation in winning product leadership, more and more design engineers are specifying Lamb Electric Motors.

Specially engineered for each product or device, Lamb Electric Motors provide the exact mechanical and electrical requirements for a specific application.

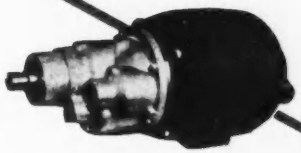
Our 34 years' experience in motor engineering frequently enables us to make product design suggestions which reduce *product* weight, provide compactness, improve performance, and lower cost.

THE LAMB ELECTRIC COMPANY
KENT, OHIO

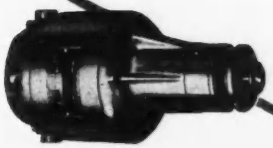


Series universal motor parts specially designed for food-mixers and sewing machines.

This small, sturdy motor can be readily adapted to a wide range of industrial applications.



Light-weight universal motor with efficient spur gear speed reducer for many types of portable equipment.



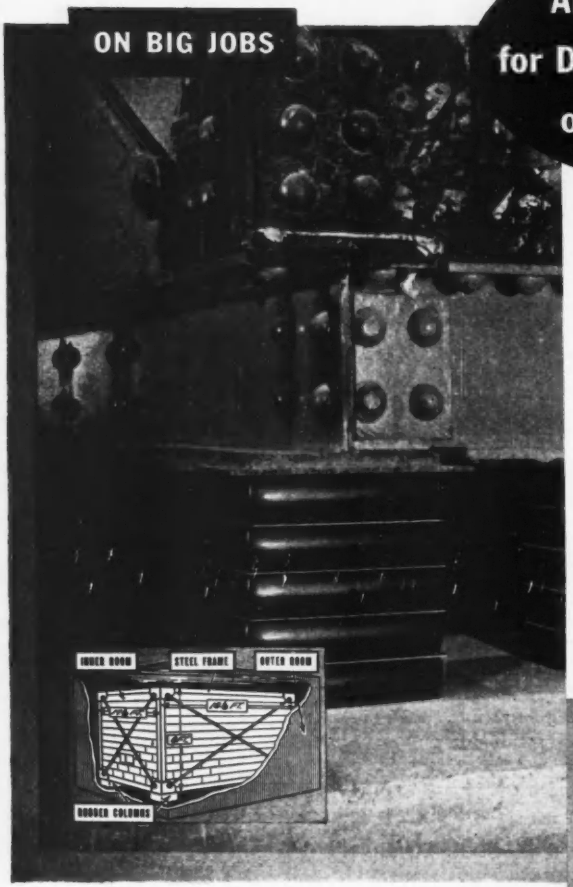
Universal motor with shaft carried on double row ball bearings; developed for use as a high-speed grinder.

Lamb Electric

SPECIAL APPLICATION
FRACTIONAL

An Engineering Service for Designers who have Noise or Vibration Problems

When you encounter a problem of vibration, impact or transmitted noise, whether your product is in the blueprint stage or already on the market, feel free to consult the engineering staff of United States Rubber Company. By means of engineered rubber parts they have solved so many problems of this kind that it is quite likely they already have the answer to yours. No product or installation is too big or too small for them.



"We want this to be the quietest room in the world," said scientists at Northwestern University. They asked the "U.S." experts to design flexible structural columns for a concrete room, weighing approximately 100,000 pounds, intended for delicate sound tests. To prevent transmission of exterior noises, and to insulate against vibration coming from without, "U.S." engineered rubber structural supports were used. Tests proved that these columns insured 98% absorption of sound: prevented transmission of external vibration.

"I want full tone quality in this loudspeaker," said a radio manufacturer. And he got it. U.S. Rubber Company scientists helped by using 3 cylindrical type engineered rubber mountings to insulate the cabinet from the loud speaker, effectively absorbing vibration and cutting undesirable noise to a minimum.

For advice on your equipment design problem involving vibration, impact, transmitted noise, write United States Rubber Co., Engineered Rubber Products Division, Fort Wayne, Ind.

MADE BY U.S.RUBBER SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

Noma Makes News

with "Hercules" Flame-Resistant Acetate

Improved designs combined with the development of a new and superior flame-resistant cellulose acetate provide ultra safety and utility in Noma's new line of illuminated Christmas tree ornaments.

Designed right, and molded with the right plastic, Noma's new "fancy figures" are shaped to give generous clearance around bulbs. Clever venting keeps them cool, contributes to their sparkle and brilliance when lighted. They are approved by Underwriters' Laboratories, Inc. when used in listed outfits.

This new flame-resistant acetate offers all the features of regular cellulose acetate: toughness, rich color, extreme lightweight, good electrical insulation, heat resistance, and dimensional stability, plus the important advantage of being a truly self-extinguishing material which can be injection molded.

"Hercules" flame-resistant acetate is bringing added sales appeal to a growing list of electrical appliances and devices. Our technical staff invites inquiries on improving your products with flame-resistant cellulose acetate.

- TOUGH
- COLORFUL
- FLAME-RESISTANT
- LIGHTWEIGHT
- ECONOMICAL

ETHYL CELLULOSE · CELLULOSE ACETATE · NITRO CELLULOSE

HERCULES POWDER COMPANY
INCORPORATED
904 Market Street, Wilmington 99, Delaware

"HERCULES" IS REG. U. S. PAT. OFF.

CP9-7

no more hand-me-downs

Stainless sheet and strip production is coming of age—no longer made on the hand-me-downs of carbon steel production, thanks to modern advances in strip mill practice. CRUCIBLE, drawing on this progress and on generations of *specialty* experience, has carried stainless development even further by building the world's first complete mill designed *specifically* for hot and cold rolling of stainless steels. In this $18,000,000 project, every building, every piece of equipment, has been built to incorporate the *best* of accepted modern practice, PLUS exclusive features designed by CRUCIBLE's industry-famous technical staff.

Here stainless sheet and strip is produced in widths from ½″ to 50″ inclusive, in all gauges, grades and finishes. This new and important contribution to the production of stainless steel is vital news to every processor of stainless steel products. For now CRUCIBLE, one of the pioneers in stainless steels, rounds out an integrated program of stainless in all its forms—sheets, strip, plates, bars, wire, forgings, castings, and tubing (manufactured by the new subsidiary, Trent Tube Co.) To this program CRUCIBLE has applied its *specialty product* methods of quality control, methods that have given CRUCIBLE leadership in special purpose steels for half a century. Data sheets for all grades are yours for the asking. Your inquiries will be welcomed.

CRUCIBLE STEEL COMPANY OF AMERICA
405 Lexington Ave., New York 17, N. Y.
Branches, Warehouses and Distributors in Principal Cities

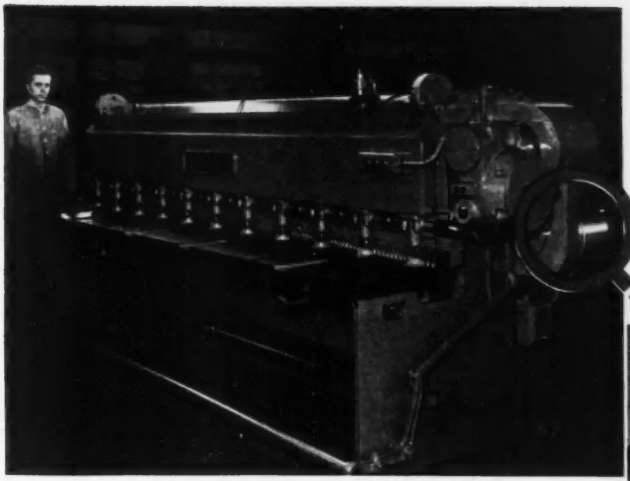
for stainless sheet and strip

CRUCIBLE first name in special purpose steels

hot and cold rolled **STAINLESS SHEET AND STRIP**

STAINLESS • HIGH SPEED • TOOL • ALLOY • MACHINERY • SPECIAL PURPOSE • STEELS

A.O. Smith Builds ELECTRIC MOTORS

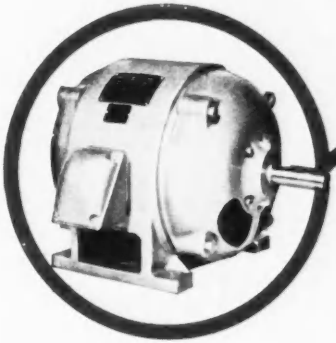


for hundreds of products, including CINCINNATI SHEARS

Ask the A.O. Smith man about electric motors for both special and standard uses

To help you integrate motor design with product design—to achieve the most efficient and most economical operation—the research and engineering staff at A. O. Smith is at your disposal. If you seek improved performance in your product, if you require special characteristics in your power component, in custom-built or in standard electric motors, consult the A.O. Smith man. Typical of his service is the machine tool, illustrated here, of The Cincinnati Shaper Co.

WRITE FOR A.O. SMITH BULLETIN No. EM-152



CINCINNATI ALL-STEEL SHEAR

Cuts sheet metal to micrometer-measure tolerances, and shears with this accuracy at high speed. Automatic hydraulic hold-downs clamp any gage metal with firm pressure. Fine adjustments for the 4-edge knives assure more efficient use of the keen edge and longer life. All standard Shear sizes, 10 gage to 1¼ inches.

A. O. SMITH ELECTRIC MOTOR for the Cincinnati Shear is 5 hp, 1800 rpm, a punch-press type with high starting torque, 8 to 13% slip—an open motor, frame 225, with pre-lubricated double shielded ball bearings.

A.O. SMITH INCORPORATED 75th ANNIVERSARY 1876 - 1949

24-HOUR MOTOR SERVICE

To more than 200 authorized service stations, A.O. Smith Product Service Division provides fast, low-cost electric-motor service, on a 24-hour, off-the-shelf basis. Factory Service Branches and Warehouses at Union, N.J., Chicago, Dallas, Los Angeles.

A.O.Smith

ELECTRIC MOTORS

A. O. Smith Corporation • New York • Boston • Cleveland
Atlanta • Chicago • Detroit • Milwaukee • Houston • Tulsa
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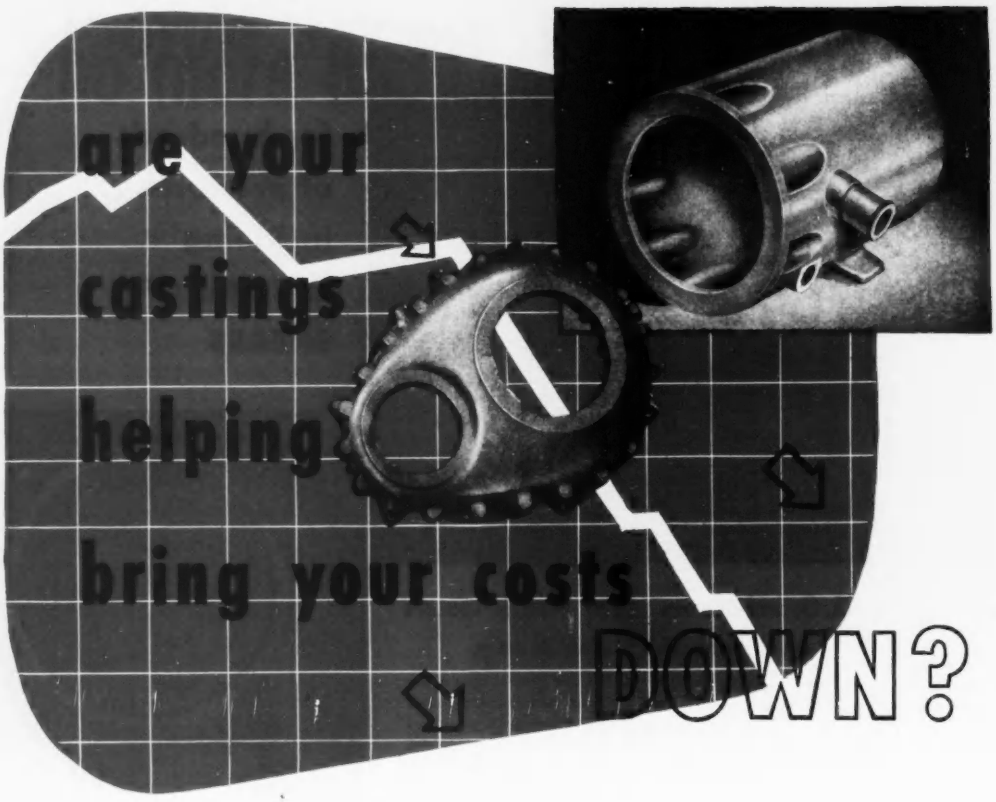

A SURVEY of your aluminum castings requirements by Permite engineers may bring you important economies.

Structural design recommendations, made by Permite aluminum casting specialists, often increase the originally planned strength and bring savings in metal and machining, without affecting the utility of the part.

Also available to you, is Permite metallurgical cooperation in selecting the best alloy to provide all the desired qualities in the casting at the *lowest ultimate cost.*

The vast Permite foundries provide today's most advanced facilities for producing aluminum castings by the permanent mold, semi-permanent mold, sand or die casting processes. Complete laboratory control and strict inspection procedures guard the quality of your castings from start to finish.

Permite service and castings are helping many manufacturers bring costs down. Submit blue prints for recommendations and estimates on your castings requirements.

PERMITE

ALUMINUM INDUSTRIES, INC.

CINCINNATI 25, OHIO

ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS

there's a Styron formulation to fit your product requirements

The good physical characteristics of Styron 683, combined with ease of molding, and the plus value of improved heat resistance indicated its use for the Ansco Rediflex Camera Case molded by Ansco, Division of General Aniline & Film Corporation, Binghamton, New York.

Styron 666 in the Curtiss Candy Dispenser by Plastics Manufacturing Company, 825 Trunk Ave., Dallas 10, Texas and Styron 411C in the Utility Tray by Columbus Plastic Products, Inc., 1625 W. Mound St., Columbus, Ohio, were used for their physical strength, high clarity and molding performance that leads to quality and economy in the product.

STYRON

Plastics Division—T-51
THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

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Whatever your product requirements may be, there is a Styron (Dow Polystyrene) formulation produced that can meet your job specifications.

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WHEN DAIMLER INVENTED
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Koven

WAS MAKING INDIVIDUALIZED
EQUIPMENT PARTS

KOVEN can recall a long succession of "firsts" in American history—because the original KOVEN plant was established over 68 years ago. Our engineers and craftsmen have had long years of experience in developing and perfecting the most efficient methods for fabricating individualized equipments parts. Many leading equipment manufacturers call on KOVEN to produce a part or parts of their finished product because it is done faster and often more economically in one of KOVEN'S vast plants. Our complete modern facilities include machine, welding, galvanizing and painting shops. X-ray inspection insures quality control. Call or write for a consultation with one of our representatives—no obligation.

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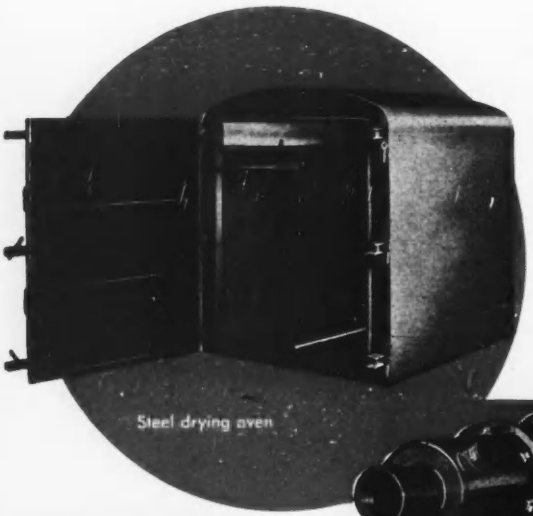
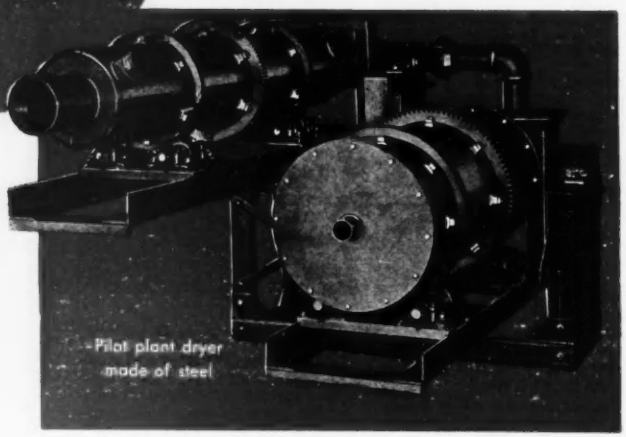


Steel drying oven

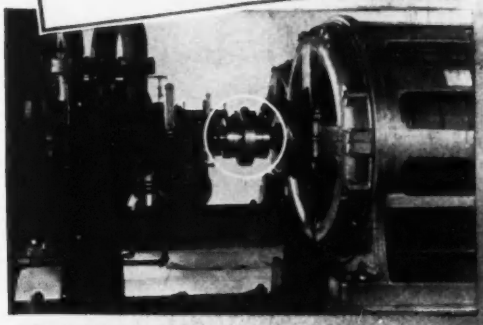
Plants:
Jersey City, N. J. Dover N. J.



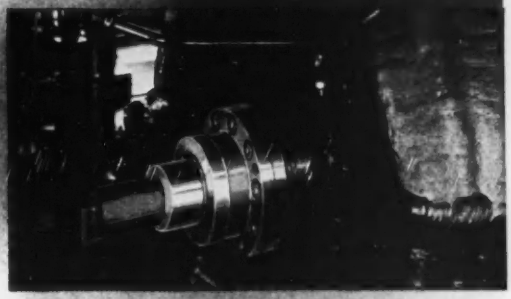
Pilot plant dryer made of steel

KOVEN FOR INDIVIDUALIZED EQUIPMENT PARTS SINCE 1881

How Fast's Exclusive Metal to Metal Seal Boosts Your Plant's Production



OIL REFINERIES insist on Fast's Couplings to keep their vital machinery *running*, because they know Fast's virtually *eliminate* all shutdowns due to coupling failure! This Coupling has been in service since 1931.



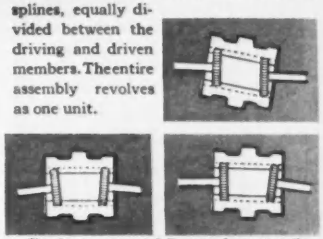
HEAVY INDUSTRIES specify Fast's Couplings because they compensate for shaft misalignment and have *no perishable parts* of any kind to fail!

YOUR production figures *go up* and *stay up* when your vital equipment is protected with Fast's Couplings, because Fast's virtually eliminate all shutdowns due to coupling failure. Fast's use no perishable parts or packing rings . . . they are the *original* gear-type coupling that *really* guards load-carrying oil from moisture, abrasive dust and grit! Fast's have *exclusive* "rocking bearing" principle that gives *sure* metal-to-metal seal.

When you specify Fast's you get years of top engineering experience, Koppers' high standard of workmanship, and unexcelled coupling service including available parts if required by change of drive, *even if your Fast's have been running for 30 years*. You save money, eliminate bottlenecks with Fast's on the job, because machine and motor life is prolonged, upkeep costs are cut, shutdown losses reduced. Find out about Fast's! Use the handy coupon, or write today for free catalog. Address: Koppers Co., Inc., Fast's Coupling Dept., 279 Scott Street, Baltimore 3, Maryland.

FAST'S COUPLINGS COMPENSATE FOR ALL MISALIGNMENT

The floating sleeve takes a neutral position. All forms of misalignment are compensated for between the lubricated faces of the splines, equally divided between the driving and driven members. The entire assembly revolves as one unit.



The above exaggerated diagrams demonstrate the Fast's principle.

KOPPERS **FAST'S** *Self Aligning* **COUPLINGS**

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Please send me your new Fast's Coupling catalog which contains all the facts and specifications.

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ARC WELDING CUTS SHOP LOSSES ...lowers manufacturing costs

By A. G. Kullberg, Assistant Chief Engineer
Bay City Shovels, Inc.
Bay City, Michigan

BY converting many of our power shovel parts over to welded construction, we have cut our manufacturing costs. Component parts that once required several weeks to complete are now being produced in as little as 10 days. Important also is the greater flexibility gained by reducing the number of patterns and the dependency on outside sources for cast materials, thus permitting product changes more quickly and at less expense.

Many of our power shovel parts are now fabricated from steel plate and from standard mill shapes. Formed parts are held in simple clamp fixtures and assembled by arc welding with Lincoln "Fleetweld 7" electrodes and Lincoln "Shield-Arc" DC welders

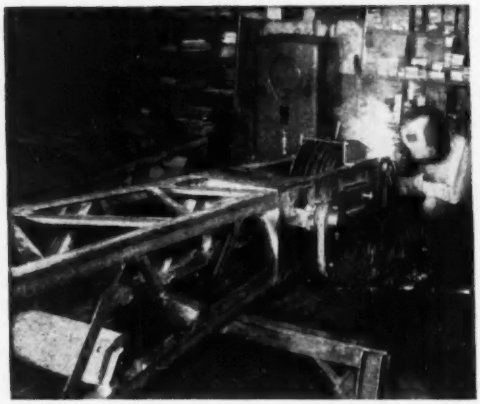

Fig. 1. *Rigid, strong and lightweight . . . This sheave-cage-to-boom assembly is typical of the high quality achieved at Bay City Shovels, Inc., Bay City, Michigan, with Lincoln "Fleetweld 7" electrodes and "Fleetwelder" AC machines.*

or "Fleetwelder" AC arc welders. The AC arc welders are used on boxed-up members where arc blow otherwise limits the use of high welding currents.

Our shop today is using arc welding to fabricate such shovel parts as buckets, booms, power transmission gear cases and motor mounts where strength is a prime requisite. We also build many of our smaller operating parts like handles, links and levers with arc welding—including sheet metal work up to 12 gauge for guards and cabs.

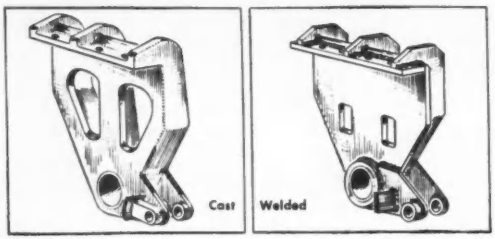

Fig. 2. Lowers cost 30% on Dipper Handle Yoke . . . *Eliminates need for more costly castings by fabricating part from lower cost steel plate and standard mill shapes.*

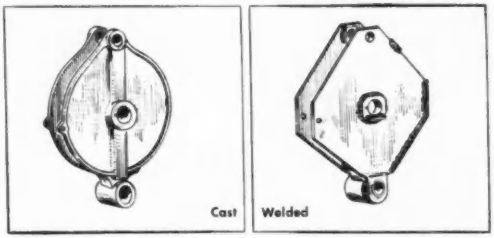

Fig. 3. Cuts material costs 54% on Dipper Sheave Cage . . . *Also eliminates excessive straightening and chipping formerly needed before machining. Total cost reduction on this part is 28%.*

The above is published by **THE LINCOLN ELECTRIC COMPANY** *in the interests of progress. Machine Design Studies are available to engineers and designers. Write on your letterhead to The Lincoln Electric Company, Dept. 38, Cleveland 1, Ohio.*

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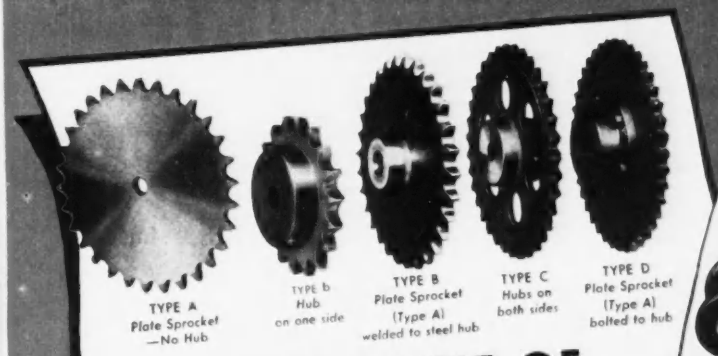

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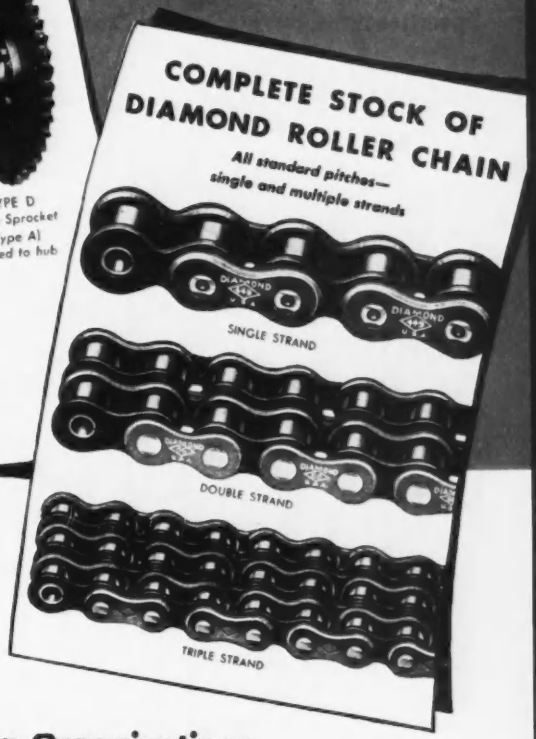

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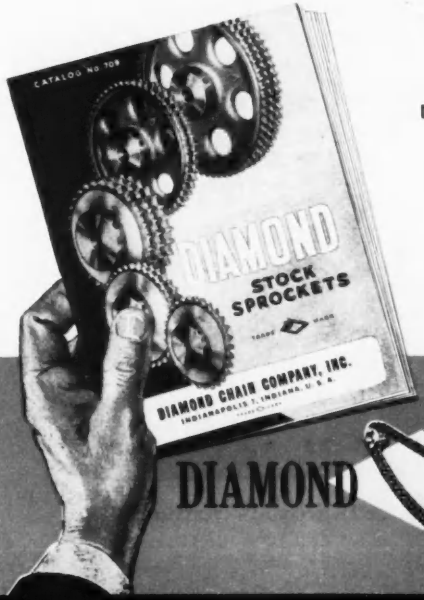

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COLD SHOULDER!

Specifications for aircraft hydraulic control valves had this designer roped and tied. Make it small! . . . Make it light! . . . Make it strong! . . . Make it cheap! He knew magnesium filled the bill for lightness and strength . . . but gave it the cold shoulder. He took his problems to Aluminum Company of America, light metal headquarters, and learned surprising things. Simple shop practices make handling magnesium no problem.* He discovered, too, that every month fellow manufacturers are using over a million pounds of magnesium.

He found that immediately-available magnesium forgings were plenty strong, light and small enough to beat the specifications. Cheap to finish, too, for magnesium machines best of all commercial metals. He got books on designing and fabricating magnesium, plus all the technical aid he needed. He says his M. E. Degree stands for Magnesium Enthusiast, too. *No change in insurance rates.

These two, free books on magnesium and our broad technical experience can help your products, too. Write Aluminum Company of America, sales agent for American Magnesium Products, 1702J Gulf Building, Pittsburgh 19, Pennsylvania.

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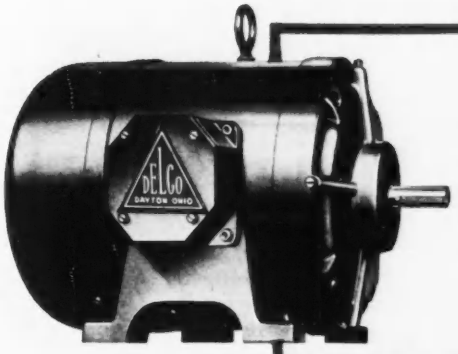
Watching production pennies?

Don't let dollars slip through your fingers!

You hear the same story everywhere. Management has laid down the law: "Get the price down per unit. Cut costs. Take out every penny you can."

That's a sound policy today, as competition gets keener. BUT . . . it can lead to *waste* and *increased costs*—lose dollars for every penny saved—if it is applied indiscriminately to production machines and motors.

Rugged, dependable Delco motors . . . built the way production men *want* their motors built . . . are the *lowest cost insurance* you can buy to keep production rolling, eliminate machine down-time caused by motor failure. Don't sacrifice other savings by taking a chance on over-age or under-built motors. Let Delco Motors help you reduce costs by raising production efficiency.



HERE'S THE "WORK-HORSE" OF YOUR PRODUCTION LINE

Size up for yourself the *extra* care and features that go into Delco Motors for *extra* performance.

- Positioned Bearings
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- Delcote Coil Insulation
- Dynamically-Balanced Rotor and Shaft Assembly
- Corrosive-Resistant Cast Iron Frame
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Call or write Delco Products, Dayton, Ohio or our nearest sales office.

DELCO MOTORS

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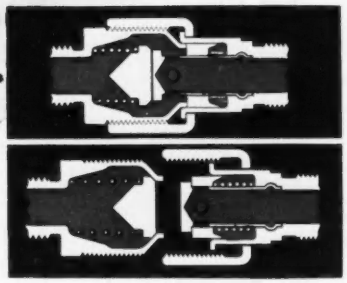
Aeroquip

SELF-SEALING COUPLINGS

Type 5100



With the installation of Aeroquip Self-Sealing Couplings, fluid-carrying lines can be disconnected without loss of liquid or inclusion of air upon reconnection. Cooling units can thus be exchanged or serviced in less time, without discharging the lines.

Aeroquip Self-Sealing Couplings are suitable for lines carrying hydraulic fluids, oils, fuels, coolants or refrigeration gases. Write for further details.

Aeroquip for better performance, maintenance and service

AEROQUIP CORPORATION

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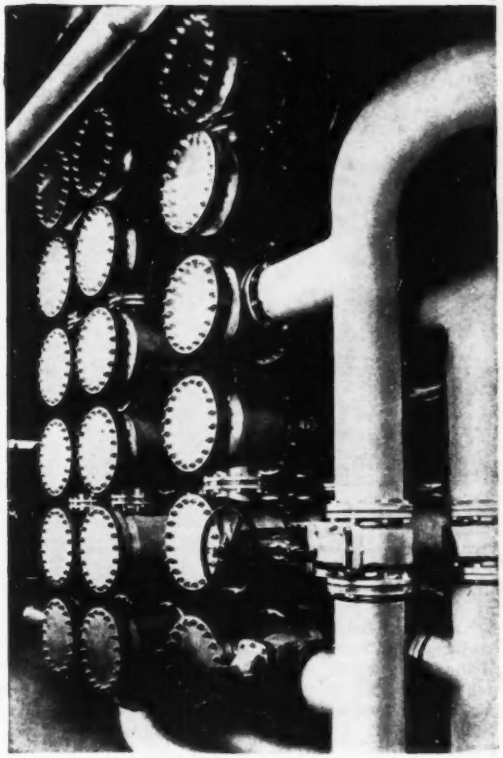
AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U. S. A. AND ABROAD

TRENT

tubing chosen for world's largest sulfite liquor alcohol plant



Stainless steel heat exchangers for cooling waste sulfite liquor to fermentation temperatures in the alcohol process.

Using waste sulfite liquor from the adjacent Gatineau Mills of the Canadian International Paper Company, the new $3 million plant of Commercial Alcohols, Ltd., of Montreal, has commenced production with a capacity of 9,000 U. S. gallons of alcohol per day.

Design, engineering and construction were carried out by Vickers-Vulcan Process Engineering Company, Ltd., a joint subsidiary of The Vulcan Copper and Supply Company and Canadian Vickers, Ltd.

The extensive use of stainless steel throughout the processing is a significant endorsement of the reputation stainless steel has established in the pulp and paper and the chemical industries. To this reputation TRENT has made important contributions, particularly by demonstrating the advantages of *precision-finished* tubing—machine-formed, machine-welded and machine-sized for uniformity from 1/8" to 30" inclusive.

It is noteworthy, therefore, that TRENT tubing was chosen for all services requiring stainless steel piping and tubing, including sulfite liquor lines, heat exchangers, and other stainless steel process piping in the world's largest sulfite liquor alcohol plant. Perhaps *you* have an application that can best be solved by TRENT tubing. We will be glad to give any desired assistance. Informative data on request.

TRENT TUBE COMPANY
Subsidiary of Crucible Steel Company of America
General Office and Plant—East Troy, Wisconsin
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TRENT STAINLESS STEEL TUBING

Job File No. 1949

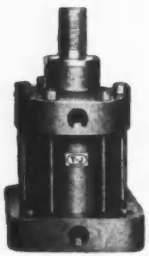
MALLEABLE NUT PRODUCTION

Fully Automatic

CONTROLLED BY T-J CYLINDERS

All moving parts are controlled hydraulically by T-J Cylinders —on this Malleable Nut Production Machine designed and built by Roy Hays & Associates, Rockford, Ill., for the Wagner Malleable Products Co., Decatur, Ill.

It's *fully automatic*—the operator only places nuts in stations. Nine T-J Cylinders, 40 ton to ½ ton, help complete the job of cutting off sprue, sizing, boring, facing, chamfering and threading 2,500-¾ std. pipe thread nuts per hour.



For your tough jobs of power movement —pushing, pulling or lifting—*save labor, speed production* and *cut costs* with T-J Air and Hydraulic Cylinders! Many standard sizes and styles . . . both cushioned and non-cushioned types . . . 100 lb. or 50,000 lb. Precision-built for long-life dependability. Write for latest catalogs. The Tomkins-Johnson Co., Jackson, Michigan.

FOR POWER MOVEMENT IN ANY DIRECTION

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Karp makes cabinets tiny or TITANIC!

From a simple, inexpensive metal box to the most elaborate housing—we are equipped to build cabinets and enclosures of any kind.

We have no ready-made stock items. Each job receives custom workmanship. This permits flexibility in your specifications, yet our modern production methods keep prices in line with competition.

Our long-experienced craftsmen, aided by the most up-to-date mechanical facilities, impart to each job, big or little, the unmistakable mark of superior workmanship. This gives added value to your finished product. Attention to the most minute detail means complete uniformity that makes your final assembly operations easier and less costly.

Our vast accumulation of stock dies often saves our customers the expense of special dies. Painting and finishing are done in an ultra-modern air-washed atmosphere—dustproof.

From design to delivery we offer you superior work and service in sheet metal fabrication. Tell us your needs. Write for informative literature.

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Engineering News

No. 5

NEW! SEAL RINGS FOR CORROSIVE CHEMICALS

Recent developments in Stackpole carbon-graphite shaft seal rings and washers include types that are highly effective in the pumping of acids and other corrosive chemicals. In addition, Stackpole offers unsurpassed facilities for engineering suitable grades for practically any requirement. Many grades are available and can be produced to suitable tolerances and specifically designed for operation against plates of bronze, brass, aluminum or other materials. Friction is greatly reduced and such unfavorable factors as tamping, packing and tightening are eliminated. Nor is there any danger of shaft abrasion when these composition seals are used!

Practically every application presents a different set of problems. Hence, Stackpole engineers welcome full details of your requirement on which their recommendations and sample seals or washers can be based. You be the judge!

HERE'S SIMPLIFIED ULTRA-CRITICAL RESISTANCE OR VOLTAGE CONTROL

Continuously adjustable rheostats formed of piles of Stackpole carbon and graphite discs provide the ideal means of varying either resistance or voltage with maximum precision and smoothness simply by applying pressure to the piles. Applications range from generating equipment voltage regulators to line, speed and pressure regulators, continuously variable rheostats, pressure indicators and others. Recent Stackpole developments in this field include a special carbon-graphite mix which enables a single pile of only 39 discs to assure the high resistance needed for a sewing machine control previously involving two piles totalling 150 discs.

If you have a possible application, why not submit details to Stackpole for recommendation?

DASH POT PLUNGERS WITHOUT LIQUID LUBRICANTS

Few applications better illustrate the versatility of Stackpole graphite than its use for dash pot plungers—for the simple reason that the static friction of graphite against the smooth metal cylinder is not much greater than that of the sliding friction. No liquid lubricants which would be adversely affected by temperature changes are required. Thus the damping coefficient of a graphite plunger is determined almost entirely by the viscosity of the air itself. Stackpole facilities in this specialized field provide for the design and production of eminently satisfactory plungers for practically any dash pot need.

LOW-FRICTION BEARINGS

OF CARBON AND GRAPHITE

The use of self-lubricating bearings of carbon and graphite composition holds interesting possibilities for a wide variety of modern equipment. Units can be molded rather inexpensively to suitable tolerances and both the composition of the bearing mix and the shape of the finished piece can readily be designed for maximum efficiency. Beyond this, the graphite greatly decreases both friction and wear by coating *both* surfaces. Stackpole has achieved considerable success in this field and would like to tackle additional bearing problems where carbon and graphite compositions may hold the answers.

Why not send full details of your application for recommendation by Stackpole engineers?

GET THIS HELPFUL CARBON-GRAPHITE SPECIALTIES BOOKLET

This 44-page, profusely illustrated book has been prepared to help you evaluate the possibilities of components of molded carbon, graphite and powdered metal composition in a broad range of modern equipment. Included are details on Stackpole tube anodes, battery carbons, ground rods, contacts, carbon piles, chemical carbons, friction segments, clutch rings, brazing and welding carbons, carbon molds and dies and many other products.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

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The material that's making news today

For over twenty-five years, Plymetl — a Haskelite material — has helped designers and engineers build greater performance, durability and sales appeal into their manufactured products. Its use eliminates deadweight, and makes complicated framing members and fastenings unnecessary. There is only one Plymetl . . . Haskelite Plymetl . . . with its performance proved. A material of many advantages, Haskelite Plymetl is easily worked with simple metalworking or woodworking tools. It can often save man-hours to a point where the final cost of the product may be noticeably reduced. The unique strength and weight characteristics of Plymetl are graphically described in the chart below. Write for complete data and samples of Plymetl.

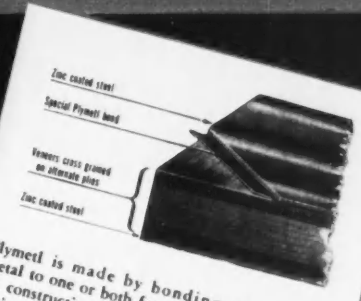
	PLYMETL UVU			STEEL U.S. STD. GAUGES			ALUMINUM B & S STD. GAUGES		
	1/4"	5/16"	3/8"	20 ga.	16 ga.	12 ga.	10 ga.	8 ga.	6 ga.
Weight in lbs. per sq. ft.	1.01	1.17	1.43	1.5	2.5	4.37	1.44	1.81	2.28
Stiffness factor E I in. ² lbs.	4,900	8,400	13,200	124	575	3,050	872	1,760	3,500

	PLYMETL EVE			STEEL U.S. STD. GAUGES			ALUMINUM B & S STD. GAUGES		
	1/4"	5/16"	3/8"	20 ga.	16 ga.	12 ga.	10 ga.	8 ga.	6 ga.
Weight in lbs. per sq. ft.	2.25	2.40	2.56	1.5	2.5	4.37	1.44	1.81	2.28
Stiffness factor E I in. ² lbs.	17,000	28,000	43,000	124	575	3,050	872	1,760	3,500

In the chart above, note that a 3/16" EVE Plymetl panel (zinc-coated steel two sides) weighs 2.40 lbs. per square foot. This is less than the weight of 16-gauge steel. However, the resistance to bending of the Plymetl panel is about 50 times as great!

Where rigidity is of prime importance, consider the following: A 3/4" UVU Plymetl panel (aluminum two sides) weighs 1.43 lbs. per square foot. The weight of 20-gauge steel is 1.5 lbs. per square foot. The Plymetl panel, though lighter in weight has 100 times the stiffness of the sheet steel.

In computing the values of Plymetl, the following is assumed: (1) The modulus of elasticity of steel, 30,000,000 lbs. per sq. in. (2) The modulus of elasticity of aluminum, 10,000,000 lbs. per sq. in. (3) The modulus of elasticity for the core material, 1,300,000 lbs. per sq. in. along the grain. 65,000 lbs. per sq. in. across the grain. (4) The thickness of steel and aluminum, .021" (27 ga.) and .015", respectively. (5) The weight of plywood plaque, 30 lbs. per cu. ft.



Plymetl is made by bonding thin sheets of metal to one or both faces of a plywood plaque. Its construction effects the most efficient distribution of these materials, combining high strength qualities of the metal surfaces with low density of woods. Result: Plymetl makes an ideal structural material, simulating an I beam with the metal surfaces taking the part of the flanges and the light weight plaque acting as the web.

Write for complete data and samples.

HASKELITE

MANUFACTURING CORPORATION

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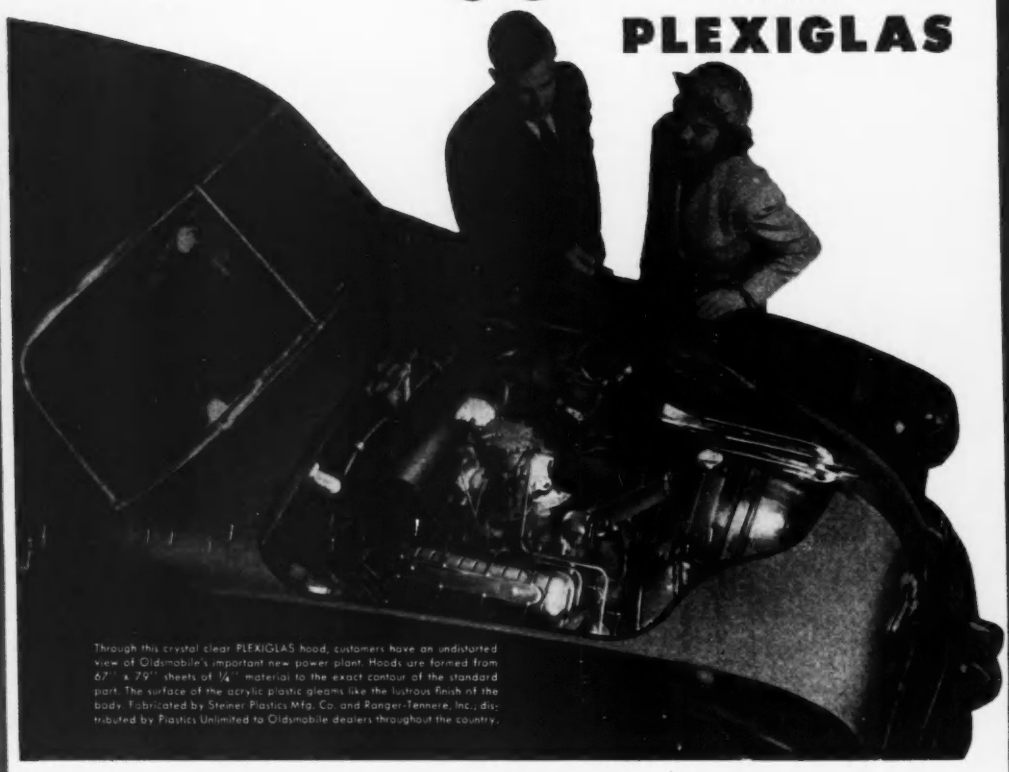
TO DEMONSTRATE THE "88" ...OLDSMOBILE Chooses PLEXIGLAS



Through this crystal clear PLEXIGLAS hood, customers have an undistorted view of Oldsmobile's important new power plant. Hoods are formed from 67" x 79" sheets of ¼" material to the exact contour of the standard part. The surface of the acrylic plastic gleams like the lustrous finish of the body. Fabricated by Steiner Plastics Mfg. Co. and Ranger-Tennere, Inc., distributed by Plastics Unlimited to Oldsmobile dealers throughout the country.

You're looking at Oldsmobile's new "Rocket" engine through optically clear PLEXIGLAS acrylic plastic. To display—with protection—its "88" model's power plant, Oldsmobile chose PLEXIGLAS transparent hoods for showroom and demonstrator models.

Rigorous road tests over General Motors' famed proving grounds showed PLEXIGLAS entirely suited to this critical job. Light, strong, shatter-resistant PLEXIGLAS passed the severe tests without damage. As a result, transparent PLEXIGLAS hoods have been installed on thousands of Oldsmobiles for both showroom and operational use.

Something *you* make or merchandise can be better displayed, beautified, or safeguarded by PLEXIGLAS. Its great strength and durability; ease of forming and machining; crystal clarity; wide range of colors; and ability to withstand outdoor exposure make PLEXIGLAS practical and economical for scores of applications.

For suggestions on the uses and advantages of PLEXIGLAS in architecture, signs and displays, lighting, transportation, safety, manufacturing or any special field, write for free literature today. Be sure to specify your field of interest—and ask for samples.

PLEXIGLAS *is a trade-mark, Reg. U.S. Pat. Off. and in principal foreign countries.*

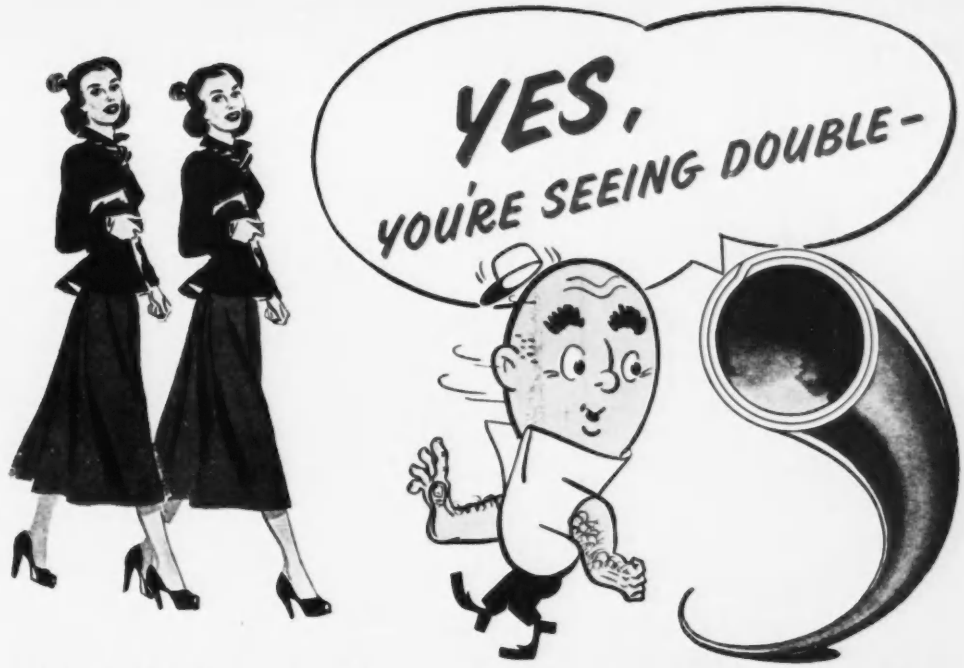
Canadian Distributor: Crystal Glass & Plastics, Ltd., 282 St. Helens Avenue, Toronto, Ontario

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

Representatives in principal foreign countries



—and it's a good sight for your eyes, too!

For you're looking at *double-walled* Bundyweld* Tubing! In steel, Monel or nickel, it's a *double*-duty, *doubly* strong, *doubly* useful tubing well worth a long second glance.

Bundyweld's patented construction doubles up with the special features of nickel and Monel to offer *advantages that no other tubing can match.* It's ductile, lightweight, faster-cooling—a real miracle tubing of industry.

Perhaps you have a new idea where an application of extra-strong, sturdy Bundyweld may help out. We *used* to think there weren't any left. But designers keep on specifying it, and uses seemingly double daily.

"Oh, yeah!" you say?

Well, maybe not *that* fast, but here are a few instances to show you what we mean. Take weather-resistant, non-sagging Bundyweld for television antennas. Or leakproof Bundyweld for radiant heating. Again, ink cartridges for ball-point pens, ledger posts in accounting books—the list is as long as it is amazing.

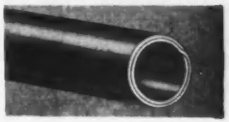
What about *your* new idea? Like some help on it? Or more information on Bundyweld? Just contact one of the representatives below, or write: ***Bundy Tubing Company, Detroit 14, Michigan.***

WHY BUNDYWELD IS BETTER TUBING

1 Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

2 This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

3 Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong ductile tube, free from scale, held to close dimensions.



4 Bundyweld comes in standard sizes, up to ⅝" O.D., in steel (copper or tin coated), Monel or nickel. For tubing of other sizes or metals, call or write Bundy.

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

*REG. U. S. PAT. OFF.

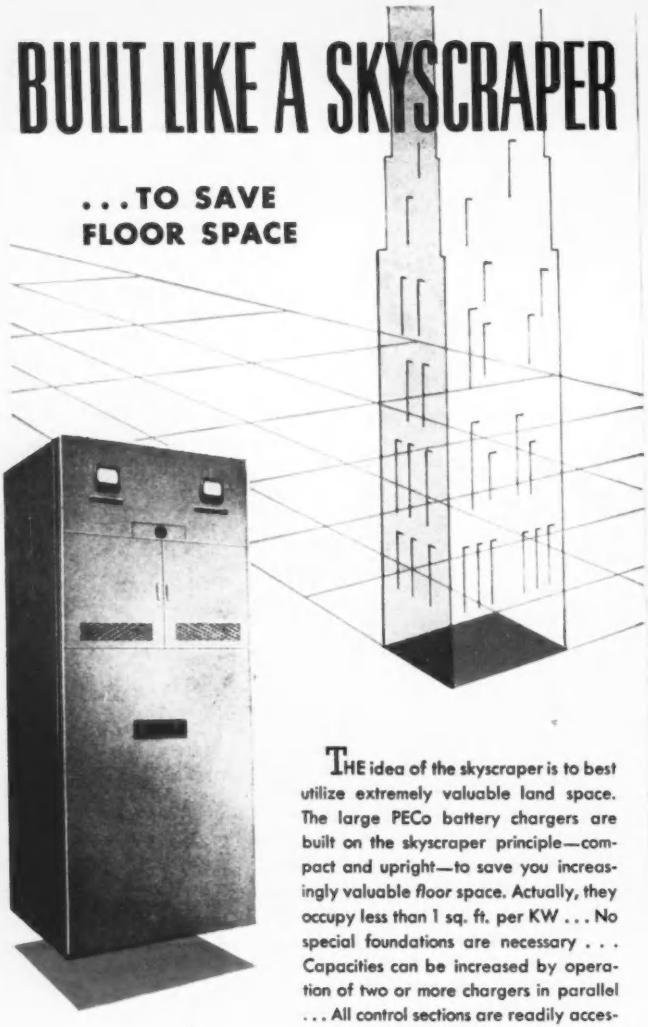
BUNDY TUBING DISTRIBUTORS AND REPRESENTATIVES

Cambridge 42, Mass.: Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.:*** Pairson-Deakins Co., 823-824 Chattanooga Bank Bldg. ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey:*** A. B. Murray Co., Inc., Post Office Box 476 • ***Philadelphia 3, Penn.:*** Rutan & Co., 404 Architects Bldg. • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** Eagle Metals Co., 3628 E. Marginal Way • ***Toronto 5, Ontario, Canada:*** Alloy Metal Sales, Ltd., 881 Bay St.

BUNDYWELD NICKEL AND MONEL TUBING IS SOLD BY DISTRIBUTORS OF NICKEL AND NICKEL ALLOYS IN PRINCIPAL CITIES.

BUILT LIKE A SKYSCRAPER

. . . TO SAVE FLOOR SPACE



THE idea of the skyscraper is to best utilize extremely valuable land space. The large PECo battery chargers are built on the skyscraper principle—compact and upright—to save you increasingly valuable floor space. Actually, they occupy less than 1 sq. ft. per KW . . . No special foundations are necessary . . . Capacities can be increased by operation of two or more chargers in parallel . . . All control sections are readily accessible. Rectifier assemblies are on removable trays to facilitate inspection or service . . . Fully automatic; electronically or magnetically controlled and regulated; accurate floating voltage control within ±1% . . . Complete range of sizes up to 10 KW . . . Write for all the facts.

POWER EQUIPMENT *Company*

Specialists in Controlled Rectifiers Since 1935

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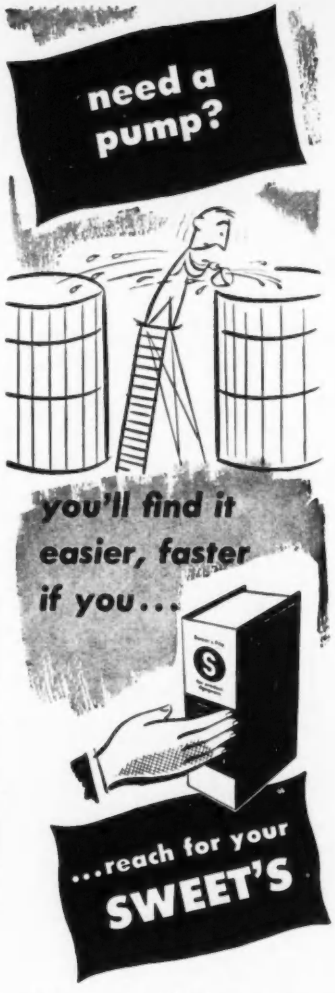

When you need specific information on materials, finishes or parts, reach for your Sweet's File for Product Designers (the big orange file). It contains 169 manufacturers' catalogs full of useful information on thousands of products . . . from absorbers—shock, to zinc. Cross indexing speeds finding.

If Sweet's File for Product Designers is not available in your office, make request immediately for application form. Files are distributed FREE to qualified organizations and individuals.

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Plastics where plastics belong

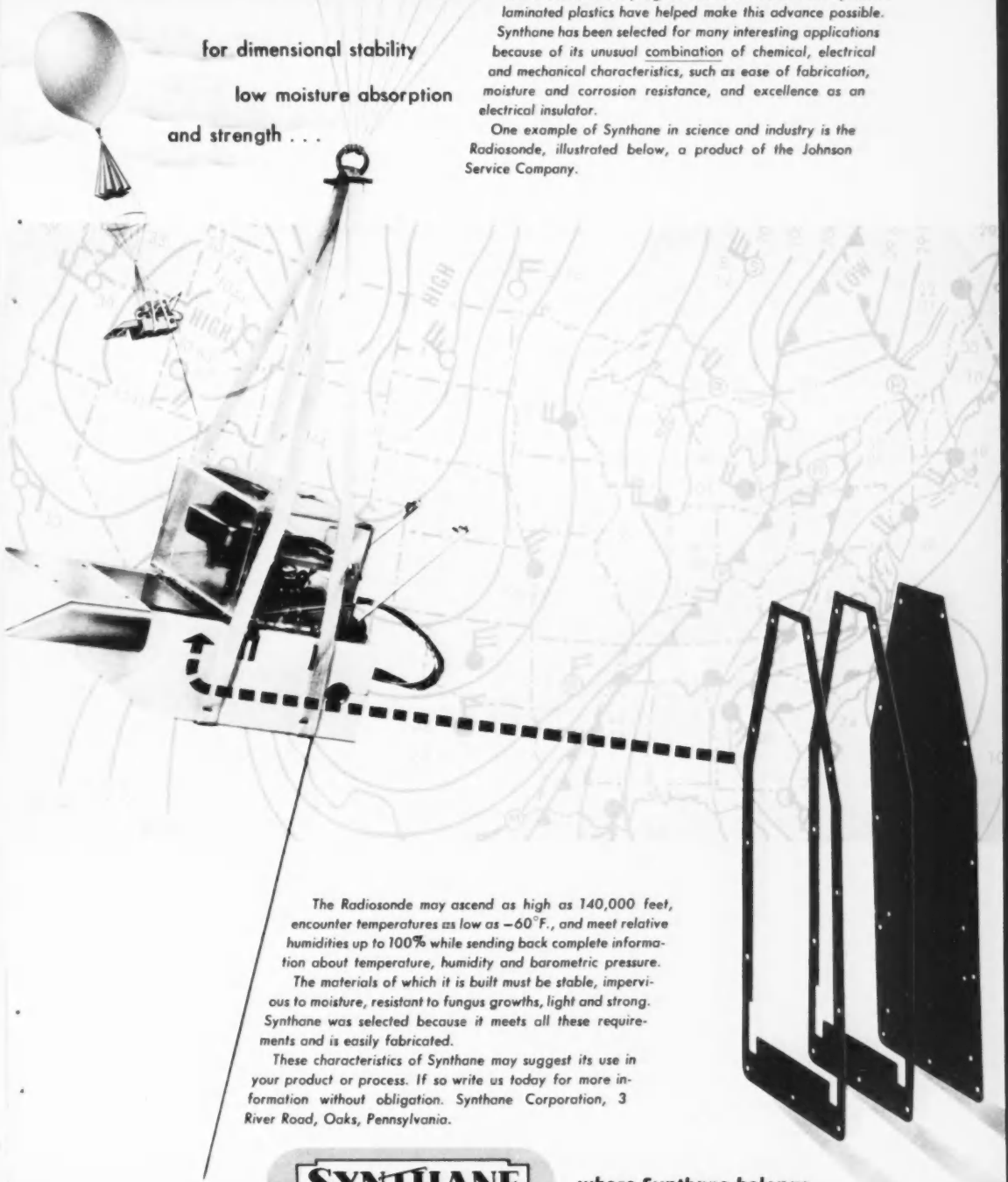
for dimensional stability

low moisture absorption

and strength . . .

"Doing something about the weather" is a field of science in which considerable progress has been made. And Synthane laminated plastics have helped make this advance possible. Synthane has been selected for many interesting applications because of its unusual combination of chemical, electrical and mechanical characteristics, such as ease of fabrication, moisture and corrosion resistance, and excellence as an electrical insulator.

One example of Synthane in science and industry is the Radiosonde, illustrated below, a product of the Johnson Service Company.



The Radiosonde may ascend as high as 140,000 feet, encounter temperatures as low as −60°F., and meet relative humidities up to 100% while sending back complete information about temperature, humidity and barometric pressure. The materials of which it is built must be stable, impervious to moisture, resistant to fungus growths, light and strong. Synthane was selected because it meets all these requirements and is easily fabricated.

These characteristics of Synthane may suggest its use in your product or process. If so write us today for more information without obligation. Synthane Corporation, 3 River Road, Oaks, Pennsylvania.

SYNTHANE

where Synthane belongs

SHEETS • RODS • TUBES • FABRICATED PARTS • MOLDED-LAMINATED • MOLDED-MACERATED

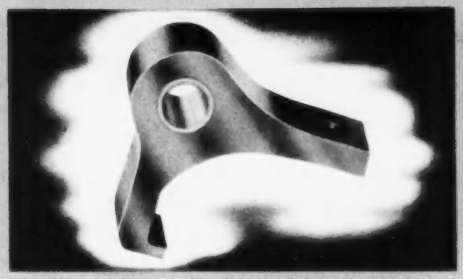
LOOK

at the extra values

Over at the right are four parts made of Synthane laminated plastics. Synthane was selected for these important jobs because of one or two mechanical, chemical or electrical characteristics. In each application the user found that Synthane was not only a better material in the major requirement but it gave him a valuable and desirable extra by reason of other beneficial properties. This is true of almost every Synthane application because our type of laminated plastics is unusual for its *combination* of values.

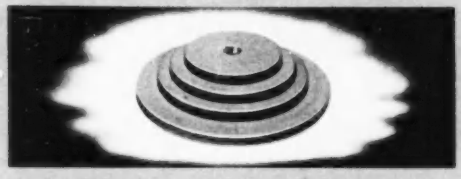
Synthane is strong, light, hard, and dense. An excellent electrical insulator, it has high dielectric strength, low dielectric constant, and low power factor. Highly resistant to moisture, abrasion, corrosion, and wear, Synthane is easily worked on production equipment. It is a *set* plastic, dimensionally stable over wide variations of temperature.

If these few of Synthane's many desirable properties and abilities suggests its use in your product or process, clip and mail the coupon today, let us help you with materials, design or fabrication of parts.

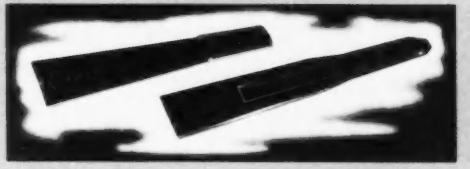


Distributor Breaker Arm. *Manufacturer sought good wear resistance and electrical insulating ability. His extra values: Impact fatigue resistance, low moisture absorption, vibration absorption.*

Piping for Nylon Sizing Machine. *Designer needed good corrosion resistance. His extra values: Light weight, strength.*



Vee Belt Pulley. *User required light weight. His extra values: Wear resistance, stability, low power loss, reduced lubrication problem.*



Hosiery Examining Form. *Processor looked for smooth, non-sagging surface. His extra values: Rigidity, light weight, black finish all-the-way-through, freedom from warping, hardness.*

FOR MORE INFORMATION ABOUT YOUR EXTRA VALUES

SYNTHANE CORPORATION, 3 River Road, Oaks, Pa.

Gentlemen:

Please send me without obligation a complete catalog of Synthane technical plastics.

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Company _____

Address _____

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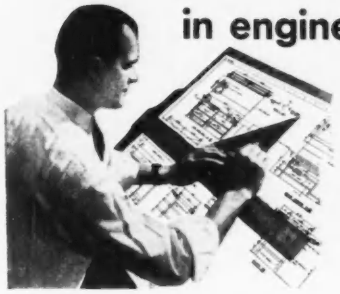
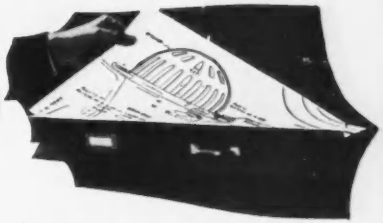
for the thousands of dollars you have invested in engineering drawings . . .



You can preserve every detail of your drawings by ordering Kodagraph Autopositive intermediates from your own reproduction department or local blueprinter. *Do this* . . . and you can keep your valuable originals in the files . . . protected against machine wear and tear, constant handling. *Do this* . . . and you'll have intermediates that set new standards for all-purpose use . . . that have dense, ink-like lines on a clear, durable, evenly translucent base. Intermediates . . . that will not smear or lose line density in handling or printmaking . . . that will produce sharp, clear blueprints and direct-process prints at uniform, practical speeds.



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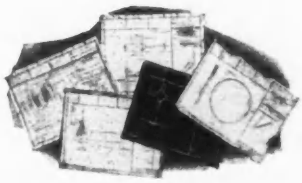
Kodagraph Autopositive Paper



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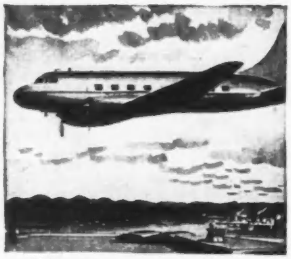

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Business Machines	Vending Machines
Controls	Radio & television tuning
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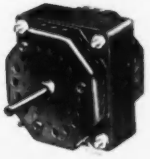
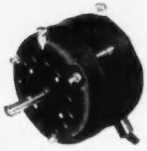
Mass production of small motors for *mass* markets at low cost—that's the job at Alliance!

Alliance motors rated from less than 1/400 h.p. on up to 1/25 h.p. are made semi-open, and fully enclosed. Some are uni-directional and others are reversible. Motors are designed for both continuous and intermittent duty loads. Covering a wide range of standard AC voltages and frequencies, Alliance offers motors of varied types with operating characteristics to fit the specific needs of small loads. Individual changes in design are available where quantity warrants.

MODEL B
4-pole shaded pole motor. Approx. 1/30 h.p. 1550 r.p.m.

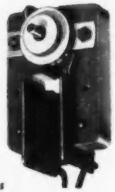




MODEL A
6-pole shaded pole motor. Approx. 1/30 h.p. 500 to 1050 r.p.m.

MODEL MS
2-pole shaded pole motor — full load h.p. .0021. Full load 2800 r.p.m.

Check these advantages!
- Low operating cost
- Low induced hum
- Low magnetic field
- Low first cost
- Cool running—quiet
- Flexible power range
- Slower controlled speeds
- Long life



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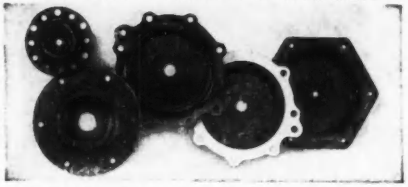

DIAPHRAGMS. We produce diaphragms of all types, with or without fabric insert, from the size of a dime up to three feet in diameter. Special stocks are compounded to resist various fluids, extremely high and low temperatures, continued flexing, or combinations of these requirements.

ACUSHNET invites problems involving the most meticulous specifications. Diaphragms are not stocked; made on special tools to order.

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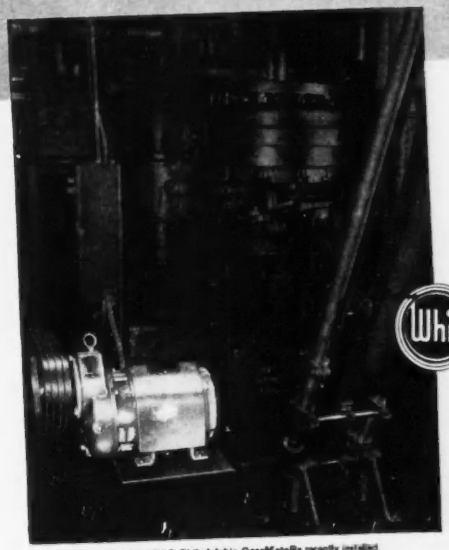
2 MORE Nationally Known Firms

WHO USE THE Philadelphia GEARMOTOR



Above: Showing one of four 3 H.P. Philadelphia GearMotoRs recently installed by the R. M. Hollingshead Corp., Camden, N. J. Motor speed—1750 R.P.M.; output speed—350 R.P.M.; Reduction ratio is 5:1. Driving a square can seamer.

Above: Showing one of two 1 H.P. Philadelphia GearMotoRs installed in the Front Royal Plant of American Viscose Corp. Motor Speed—1750 R.P.M.; output speed —125 R.P.M.; Reduction ratio is 15:1.

Here are some of the reasons why the **Philadelphia GearMotoR** is being used by hundreds of companies throughout industry: It is a self-contained, extremely compact unit that conforms to recommended standards of A.G.M.A. and N.E.M.A.; it is available in single, double and triple reductions . . . and the range of speeds run from 780 through 7.5 R.P.M.; motor rating from 1 H.P. through 60 H.P. . . . A-c or D-c. Motors are precision-built and fit perfectly with gear unit. Gears are of the helical type, long-lived and quiet in operation; made of quality alloy steel, precision machined (teeth shaved) and induction-hardened. Assembly is very simple: Motor and gear units are each self-contained, yet readily separated; gears in multi-reduction units may be inspected without uncoupling from driven machine. Lubrication is of the positive "splash type," with large reservoir. Gear housing is leak-proof, and motor, which is greased independently, has double-shielded ball bearing design.

Send for 42-page illustrated catalog, containing full information and data necessary for ordering, and please use your Business Letterhead when requesting same.

Philadelphia Gear Works, INC.

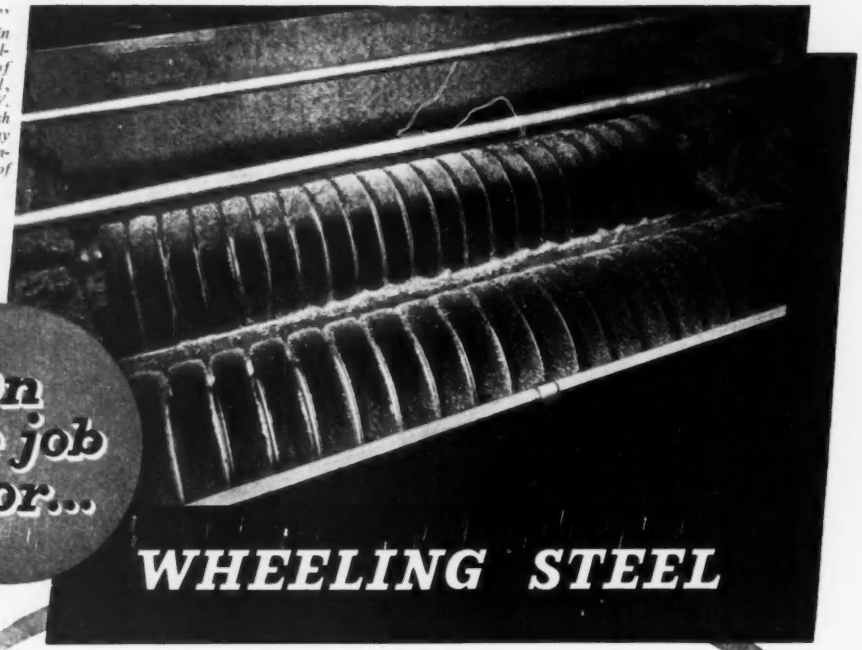
ERIE AVE. AND G ST., PHILADELPHIA 34, PA.

NEW YORK • PITTSBURGH • CHICAGO

IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

Industrial Gears and Speed Reducers
LimiTorque Valve Controls

"PITTSBURGH" Power Driven BRUSHES



A "Pittsburgh" power-driven brush in operation at the Steelcrete Division of Wheeling Steel, Beach Bottom, W. Va. This special brush is on the job every day deburring and cleaning large sheets of Expanded Metal.

On the job for...

WHEELING STEEL

Pittsburgh's ingenuity in designing special brushes for unusual jobs is sought time and time again by leading firms in almost every industry. Wheeling Steel, for example, recently put its brushing problem before Pittsburgh's staff of skilled brush engineers.

Selecting a .014 steel wire with pre-tested fast cutting qualities, Pittsburgh engineers designed and built a *Perfect Balance* rotary brush that could take a beating and come right back for more. The brush was *stiff* enough to remove stubborn burrs. It was *tough* enough to penetrate and thoroughly clean the metal. And it was *soft* enough not to impair surface texture.

The brush did the job right from the first day it was put into operation—another example of Pittsburgh's ability to cope with the most difficult brush problems.

There's a "Pittsburgh" Brush for Every Industrial Use!

- GLASS
- STEEL
- PLASTICS
- AUTOMOBILE
- RUBBER
- PAPER
- TIRE and RETREADING
- SHOE MANUFACTURING and REPAIRING

In the complete Pittsburgh line are brushes of all types, including "Perfect Balance" sections, wheels and assemblies. Consult the Pittsburgh engineering representative. He will gladly work with you in developing any type of power-driven brushes to meet your particular finishing specifications.

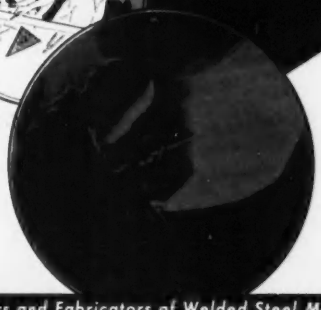
Phone or write Pittsburgh Plate Glass Company, Brush Division, 3221 Frederick Ave., Baltimore 29, Maryland

Power Driven BRUSHES

BRUSHES · PAINT · GLASS · CHEMICALS · PLASTICS

PITTSBURGH PLATE GLASS COMPANY

Steel-Weld FABRICATION



This rotating base for a locomotive crane, which was redesigned by Mahon for Steel-Weld Fabrication, is typical of thousands of Steel-Weld fabricated parts and assemblies produced by Mahon for hundreds of manufacturers throughout the country. Mahon design engineers are available to assist you in initial design or redesign for Steel-Weld Fabrication. This service, backed by craftsmen highly skilled in the welding art, and complete facilities for rough or finished machining — regardless of size or weight — assures you a better, smoother appearing job, embodying every advantage of Steel Weld Fabrication.

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Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

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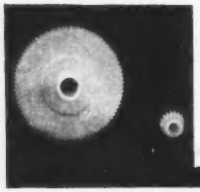
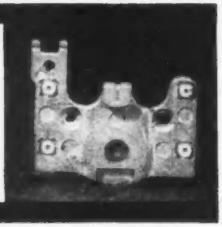
HOW TO

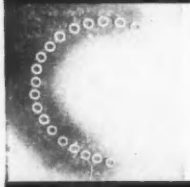
Improve Product Performance with NYLON Rod and Strip



GEARS machined from Nylon Rod have excellent wear resistance, operate quietly and do not require lubrication.

BUSHINGS for tuning devices are machined from Nylon Rod, staked into place and tapped. They have the toughness to withstand staking and the heat resistance that gives long product life.





WASHERS for holding commutator segments are stamped from Nylon Strip at minimum tooling cost. Use of nylon permits reduction in size without loss of strength, and gives heat resistance to withstand nearby soldering during assembly.

ROLLERS for aircraft use are made from Nylon Rod for a number of reasons: light weight, wear resistance, good frictional properties.

For economy along with product improvement, think about these advantages you get with Nylon Rod and Strip.

You *eliminate the need for costly molds* on short run jobs. You save time in production, with nylon that is *easy to machine or stamp*. And you avoid long waits for new molds when designs are changed.

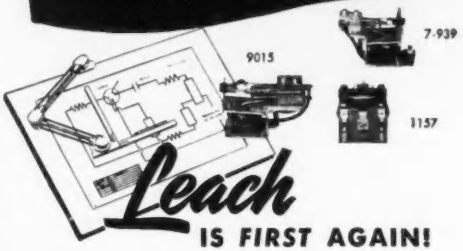
Free Folder of Useful Engineering Data

A note on your company letterhead will bring you this folder containing useful data on the physical properties and fabricating characteristics of Nylon Rod and Strip, available in several formulations.

the POLYMER CORPORATION
of PENNSYLVANIA

201 GANSTER BUILDING, READING, PENNSYLVANIA

Off the Drafting Board... INTO YOUR CIRCUIT!



Leach IS FIRST AGAIN!

Leach is *first* again with newly modified *Relays* designed, engineered and constructed to meet *your* specific requirements. For easier installation, better performance and longer life.

No. 7-939 is a newly modified motor starting relay. No. 1157 is an industrial type for handling 12½ amperes. No. 9015 is a motor starting relay designed to handle motor loads up to 3 horsepower.

Highest standards of engineering, materials and workmanship. *For better controls through better relays*—CONTACT LEACH.

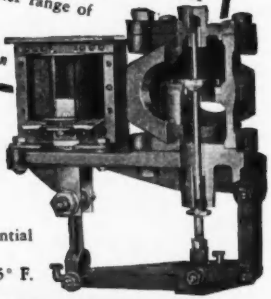
LEACH RELAY CO.

5915 AVALON BOULEVARD • LOS ANGELES 3, CALIF.
Representatives in Principal Cities of U.S. and Canada

NEW—Direct Acting Solenoid Valve for 150 lbs. Differential Pressure . . .

That's the biggest news about the new Johnson Solenoid Valve. Some sizes will operate under differential pressures up to 150 lbs., *without pilot valves*. All sizes end the time lag and wiredrawing that come with slow opening—the danger of clogging that comes with auxiliary pistons. Whatever your liquid level or flow control problems, investigate the new possibilities this Johnson design brings to solenoid valves. It offers all the basic advantages, with none of the shortcomings, for a far greater range of applications.

GET ALL THE FACTS
Write for new bulletin



WHERE CAN YOU USE THIS AUTOMATIC VALVE?

- Immediate full flow
- No pilot valves
- Up to 150 lbs. differential pressure
- Temperature to 365° F.

The Johnson Corporation

813 Wood St. Three Rivers, Michigan

Parker-Kalon GROUND THREAD Socket Set Screws are *Aces high* with shop men

"You can count on uniform, dependable Class 3 fit with P-K Socket Set Screws."
"True ground finish — none of the imperfections you get with ordinary cut thread set screws."
"Clean starting threads speed assembly work and improve production."
"You don't need to be a skilled mechanic to detect the difference — you can feel it."

Compare! Write for Samples!

See why P-K Ground Thread Socket Set Screws speed assemblies, improve strength and safety. Thread grinding, once reserved for screws used in the finest precision equipment, now gives Parker-Kalon Socket Set Screws the accurate finish and faultless contour that mean faster assembly and more sales for your products. Write for samples today.

SEND FOR STOCK LIST NOW

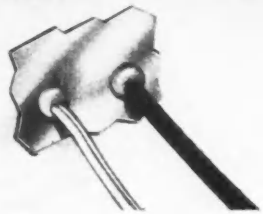
PARKER-KALON® CORPORATION
200 Varick Street
New York 14, N. Y.

AVAILABLE THROUGH ACCREDITED DISTRIBUTORS IN EVERY INDUSTRIAL AREA

Something New has been Added

TWO LOW COST HEYCO STRAIN RELIEF BUSHINGS

(No. 2-P for XT-20 CLOCK WIRE
No. 3-P for POSJ-64 and POT-64 SIZES)



Anchor your cordset to your electrically operated machines, appliances and equipment to insure maximum product life!

The Heyco

1. Absorbs cord pull, push & torque
2. Insulates wire from chassis
3. Prevents wire from fraying
4. Eliminates tying wire knots
5. Improves product appearance

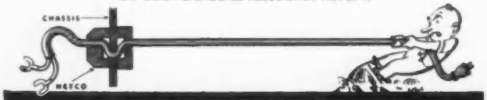
● The Nylon Heyco insulating grommet grips the wire in a vise-like grip yet will not injure it in any way. Your product will be a better product with Heyco.

OTHER HEYCOS IN SIZES TO ACCOMODATE WIRES UP TO 3/4" DIAMETER

HEYCO

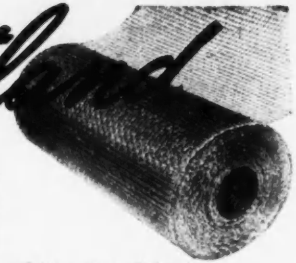
HEYMAN MANUFACTURING COMPANY
Kenilworth 3, New Jersey

In Canada Approved by
Canadian Standards Association No. 8919



HEYCO ELIMINATES STRAIN ON TERMINALS

Cortland BRAND INDUSTRIAL WIRE CLOTH



For Mechanical and Structural Design

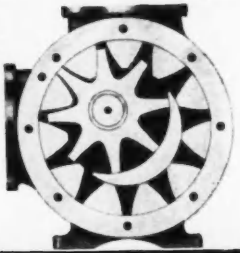
Whatever your design problem with wire cloth for mechanical or structural parts, call on Wickwire Brothers, Inc. — specialists in wire manufacturing since 1873 — for experienced information. Wickwire's CORTLAND Brand Industrial Wire Cloth is made to meet your specifications —

Sizes: One inch to 30 Mesh
Weaves: Square and special
Metals: Steel, Copper, Brass, Bronze, Aluminum, Stainless Steel, etc.
Gauge: 14 to 39 and special
Finish: Tinned, galvanized, painted or plain steel.
Widths: 24"-48" standard; also narrower or wider, and slit or cut to size.

Inquiries about special grades and special applications are welcomed. Cortland Brand Industrial Wire Cloth can help you build your product better.

WB Cortland BRAND
WICKWIRE BROTHERS, INC., Cortland, N. Y.

You can PUMP IT with VIKING ROTARY PUMPS



The pump that moves any clean liquid regardless of viscosity . . . that is the Viking Rotary Pump.

Its "Gear within a Gear—2 moving parts" principle gives you this service. Its rugged construction, without small intricate parts, springs, gadgets, etc. assure long dependable life.

Viking rotary pumps are engineered for the job . . . to do the work assigned them. Ask for free folder 49SX today. Recommendations gladly given without obligation.

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AN HONORED NAME IN PUMPING

See Our Catalog In SWEETS

Viking PUMP COMPANY
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WE CAN SHOW YOU THESE

...but we can't show you

SIRVENE

That's because Sirvene means something different in every application. Primarily it is a specially compounded elastomer designed to meet a critical operational requirement. No two uses of Sirvene are alike. Every purpose, every design and every formula is individual. You, the design engineer, determine the need and type, and Sirvene engineers work with you in developing the particular part required for the efficient operation of your mechanism. The physical properties and resistance qualities are custom developed to do just *your* job.

At the same time, the name Sirvene automatically implies one of the longest experiences in elastomer development in this country. Chicago Rawhide was one of the first to pioneer in combining elastomers for the purpose of producing specified qualities and characteristics. Today, many outstanding leaders in all branches of industry depend upon Sirvene for the solution to previously "impossible" mechanical sealing and protection problems. Sirvene can also mean success in your search for an unknown pliable part.

CHICAGO RAWHIDE MANUFACTURING CO.

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Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings, and other special molded mechanical pliables

OTHER C/R PRODUCTS
PERFECT Oil Seals
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SIRVENE

THE *SCIENTIFIC* COMPOUNDED ELASTOMER

"PLASTICS ARE *RIGHT* " IF THEY'RE *MOLDED* BY *Northern*

Right in design, correct in engineering principle, and the one right compound scientifically selected to best fit the specifications of each molding job — that's the meaning of, "*Plastics* are Right if they're Molded by *Northern*".

And a goodly cross section of industry has learned this is exactly what they get when they select *Northern* to do their custom molding. Because *Northern* molders are craftsmen who have grown up with the plastic industry, they are completely familiar with *all* compounds, know *when* to use them, and *how* best to mold *each* one.

For these reasons General Mills selected *Northern* to mold the plastic handles of this Pressure *Quick* Saucepan. These *Northern* handles of a phenolic plastic can't corrode, can't rust, protect hands from heat. Put your plastic problems up to *Northern* — you'll be 100% satisfied.

Northern **INDUSTRIAL CHEMICAL CO.**

40 Years of Plastic Molding Experience

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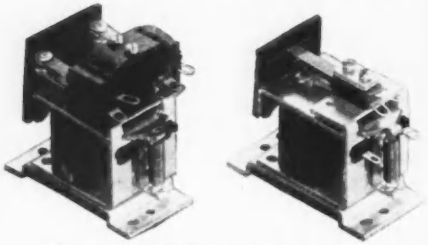
Phila. 29, Pa.
Tel. VIctor 4-8679

IF you have a relay problem requiring low cost, small size and dependable performance...



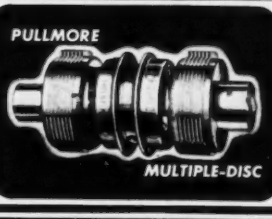
...take a look at *R-B-M General Purpose AC and DC Relays*

WRITE FOR BULLETIN AND PRICE LIST

Dept. E-9, R-B-M DIVISION OF ESSEX WIRE CORP.
Logansport, Indiana

MANUAL AND MAGNETIC ELECTRIC CONTROLS
— FOR AUTOMOTIVE INDUSTRIAL COMMUNICATION AND ELECTRONIC USE

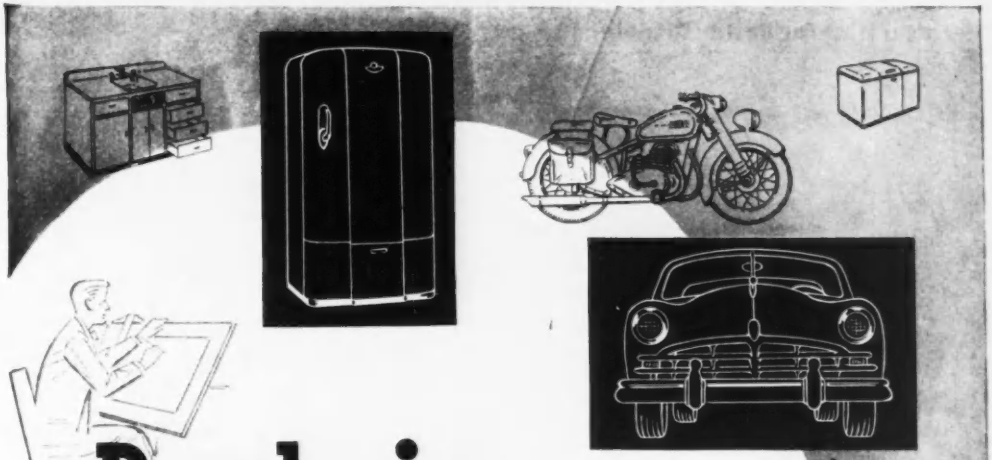
Get the Jump on Competition with



ROCKFORD CLUTCHES

Efficient power transmission control is more important in these times of keen competition than ever before. Give your product the advantage of a clutch that is exactly RIGHT for it. RIGHT *Type*, RIGHT *Size*, RIGHT *Capacity* and RIGHT *Operation*. ROCKFORD engineers are not restricted to any one or two types or sizes of clutches when making recommendations for improving power transmission control. A request from your engineering department will give your product the benefit of our long, successful experience in clutch designing, building and application. No obligation.

ROCKFORD CLUTCH DIVISION
BORG-WARNER
209 Catherine Street, Rockford, Illinois



Bonderite

means Parker quality

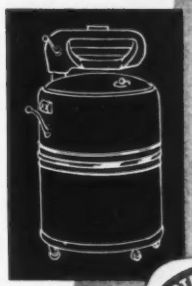
Add it to your product...

It adds quality to the quality product you build! Bonderite, Parker's corrosion resistant paint base, protects and preserves appearance and serviceability of paint finishes on metal surfaces.

Bonderite is versatile. Whatever your production—steel, aluminum, zinc, alloys of these metals, or mixed metal—it can have the benefits of Bonderite. Treatment can be by spray or immersion; automatic or hand controlled.

Bonderite quality and economy go hand in hand. Because of its dependability and the uniformity of the Bonderite coating it creates on the metal, the paint line runs smoothly and without interruption. The long-lasting fine appearance pleases both you and your customers!

Get full information on Bonderite for your painted metal product now!



Bonderite, Parco, Parco Lubrite—Reg. U. S. Pat. Off.

PARKER

PARKER RUST PROOF COMPANY
2179 East Milwaukee Ave.
Detroit 11, Michigan

BONDERITE—Corrosion Resistant Paint Base • PARCO COMPOUND—Rust Resistant • PARCO LUBRITE—Wear Resistant for Friction Surfaces

There's a Hint for Better Drawings in—

The Case of the Sightly Secretary

Engineer: *Look at the artistic revision job Miss Jones is doing.*

Draftsman: *Nice mat surface, too! That reminds me that we should make all our drawings on Arkwright Tracing Cloth. It stands revisions so much better than perishable tracing paper.*

Revision means little to Arkwright Tracing Cloth. It stands up without wearing through and re-inks without feathering. Its translucency is built in from surface to surface. For only a thrifty trifle more in cost, it will pay you to make *all your drawings* on Arkwright. Then you can count on perfect reproduction after repeated handling or years of aging in the file.

See for yourself how much better Arkwright serves. Sold by leading drawing material dealers everywhere. Generous working samples on request. Arkwright Finishing Company, Providence, R. I.

The Big Six Reasons Why Arkwright Tracing Cloths Excel

1. Erasures re-ink without feathering.
2. Prints are always sharp and clean.
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4. No surface oils, soaps or waxes to dry out.
5. No pinholes or thick threads.
6. Mechanical processing creates permanent transparency.

ARKWRIGHT

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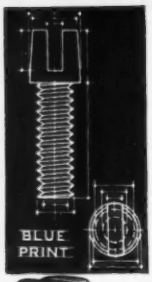
AMERICA'S STANDARD FOR OVER 25 YEARS



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QUALITY PROMCO BRAND

ENLARGED VIEW

KEEP YOUR COSTS DOWN

Progressive specializes in manufacturing special heads, threads and finishes on any metal or alloy adapted to cold upset. Please write for catalog showing many Progressive specials. Catalog includes purchasing and engineering helps.

***The* PROGRESSIVE MANUFACTURING CO.**

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TORRINGTON, CONNECTICUT

CASE REPORT No. 48 from a series of actual cases recording the successful application of BEAR DY-NAMIC BALANCING to Industry.

United States Electrical Tool Co., Cincinnati, has been Bear-Balancing fans, armatures and fan armature assemblies for five years. Daily balancing operations number from 95 to 135, require from 3 5½ minutes each.

Electric Tool Manufacturer Adds Years To The Life Of His Products Through Dy-Namic Balancing

Because Bear Dy-Namic Balancing makes for a smooth and more quietly-operating rotating assembly, free from friction and vibration, it adds years to the life of the finished product. This has been proven again and again by U. S. Electrical Tool Co. and hundreds of other manufacturers who Bear-Balance everything from tiny armatures to railroad wheels!

BEAR-BALANCING HAS PROVEN ITSELF TO INDUSTRY—most likely your particular field is represented in our Case Report file of successful users of Bear Balancing. Write for complete data, as well as a copy of the latest Bear Industrial Balancing Catalog. Bear Mfg. Co., Dept. P-5 Rock Island, Ill.

2655R

BEAR COMBINATION STATIC AND *DY-NAMIC BALANCING* MACHINES

ROLLS – "TAGGED" FOR PRACTICALLY ANY APPLICATION

Products of the *world's largest specialty roll shop* at Ansonia are made for such diverse uses as processing rubber, plastics, linoleum, celluloid, phonograph record blanks, asphalt, asbestos, ink, paint, soap and textiles; calendering paper; rolling metal; grinding flour, coffee and sugar cane; crushing tobacco stems; and extracting oil from linseed and cottonseed.

Here rolls are designed and manufactured in sizes from 5" to 72" in diameter and up to 35 feet long overall, of chilled iron, alloy iron, gray iron, Meehanite® metal or steel. Highest grade materials are used and every manufacturing step, from metal mixture and casting, to grinding and inspection, is under constant, close control.

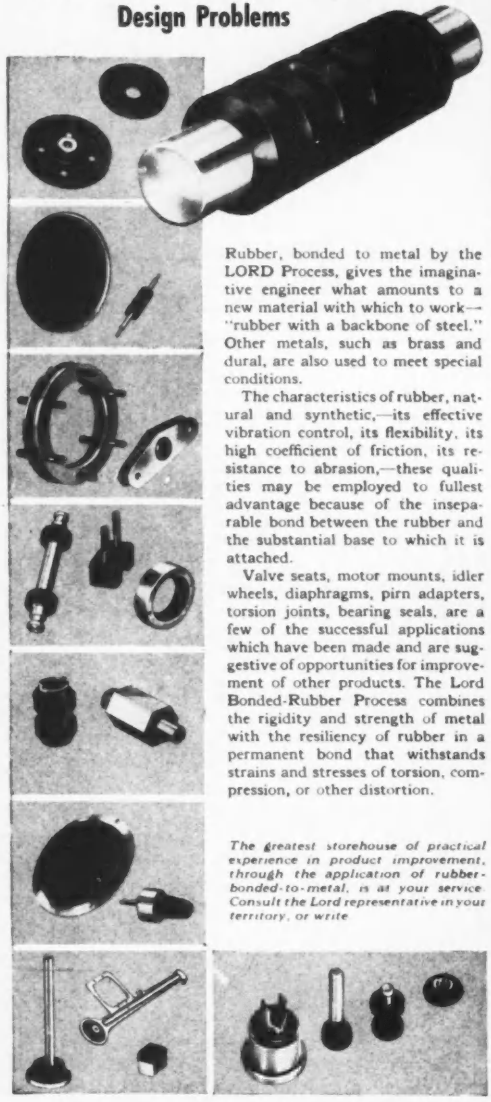
Write for information about rolls for any application. Farrel-Birmingham roll experts are ready to help you at any time.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONN.
Plants: Ansonia and Derby, Conn., Buffalo, N.Y.
Sales Offices: Ansonia, Buffalo, New York, Akron, Chicago, Los Angeles, Houston

Farrel-Birmingham®

RUBBER . . . with a backbone of STEEL

LORD BONDED-RUBBER Products Solve Some of Industry's Toughest Design Problems



Rubber, bonded to metal by the LORD Process, gives the imaginative engineer what amounts to a new material with which to work—"rubber with a backbone of steel." Other metals, such as brass and dural, are also used to meet special conditions.

The characteristics of rubber, natural and synthetic,—its effective vibration control, its flexibility, its high coefficient of friction, its resistance to abrasion,—these qualities may be employed to fullest advantage because of the inseparable bond between the rubber and the substantial base to which it is attached.

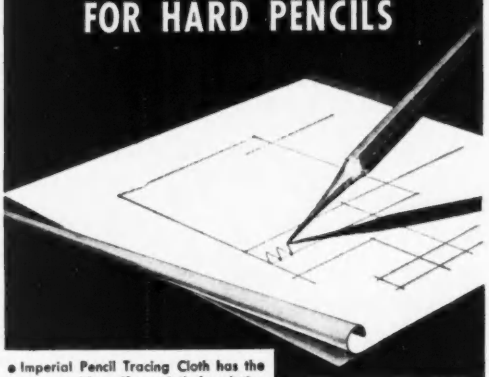
Valve seats, motor mounts, idler wheels, diaphragms, pirn adapters, torsion joints, bearing seals, are a few of the successful applications which have been made and are suggestive of opportunities for improvement of other products. The Lord Bonded-Rubber Process combines the rigidity and strength of metal with the resiliency of rubber in a permanent bond that withstands strains and stresses of torsion, compression, or other distortion.

The greatest storehouse of practical experience in product improvement, through the application of rubber-bonded-to-metal, is at your service. Consult the Lord representative in your territory, or write

LORD MANUFACTURING COMPANY, ERIE, PA.
Canadian Representative: Railway & Power Engineering Corp. Ltd

LORD Vibration Control Systems

TRACING CLOTH FOR HARD PENCILS



● Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

● Imperial Pencil Tracing Cloth is right for ink drawings as well.

IMPERIAL PENCIL TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE

SIGMA SENSITIVE RELAYS

SERIES 4

SPDT GENERAL PURPOSE. Modest cost. Suitable for aircraft applications and vacuum tube operated circuits. Precision adjustments for pull-in, drop-out. Non-inductive contact rating 2 amp. Coil resistance up to 14,000 ohms.

SERIES 5

SPDT VERY SENSITIVE. Existing performance as low as 5 milliwatts input. Undamaged by 5-30g shock. Non-inductive contact rating 2 amp. Coil resistance to 14,000 ohms.

Special Adaptations: — Built-in rectifier, two-coil differential operation, constant voltage temperature compensation.

SERIES 41

SPDT AC — DC — KEYING — DC sensitivity comparable with Series 4. AC sensitivity better than 0.5 V. A. Long life for high speed keying and counting. Mechanical life over 10^{10} operations. Contact ratings to 5 amp. or more. Coil resistance to 14,000 ohms.

SERIES 6

MULTICIRCUIT POLARIZED. Single or double windings (differential). Resistance to 25,000 ohms. Contacts up to 4PDT, 5 amp. nominal rating.

Form X (Three Position or Null Seeking) for automatic positioning, 2 way process control, etc. Form Y (biased — spring return). Used as conventional sensitive Relay, requiring complete contacts. Responds to D. C. of only one polarity. Form Z (Latching — permanent magnets). Longer life, greater resistance to vibration than mechanically latch electrical reset relays.

SERIES 7

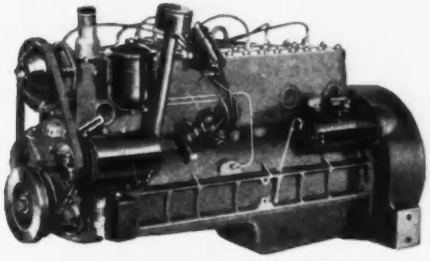
HIGH SPEED POLARIZED. Single or multiple windings up to 14,000 ohms (single). Fully balanced armature. 2 amp. nominal rating. Especially designed for repeating telegraphic signals at speeds up to 250 words per minute. Exceptionally free from distortion and chatter. Long life. Forms X, Y, Z available. (See Type 6 above).

Most Sigma relays are available in a variety of enclosures including hermetically sealed cases. Write for fully descriptive catalog.

Sigma Instruments, Inc.
Sensitive RELAYS
70 CLYDON ST., BOSTON 21, MASS.

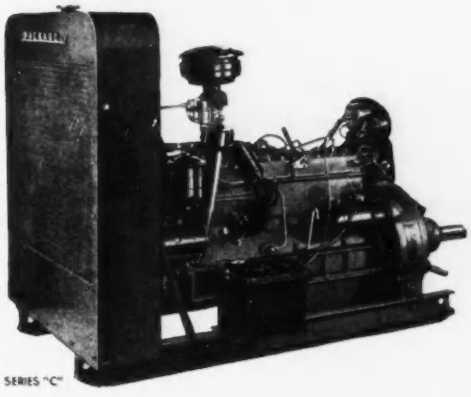
There's a Packard Industrial Engine to meet your own special requirements!

Yes, Packard Industrial Engines are now available in four series—16 models. All specially engineered for specific industrial applications. All combining rugged durability with amazing fuel economy and low upkeep and operating costs. And the initial cost is *low!* Power ratings up to 96 HP.



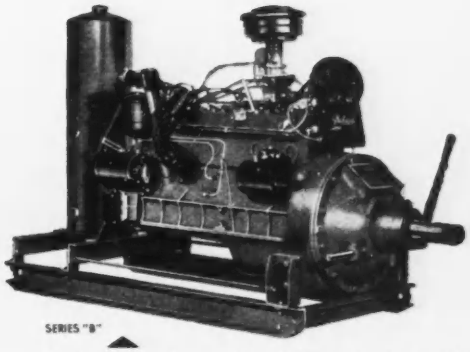
SERIES "A"

Here Packard combines rugged dependability with amazing thrift. Series "A" engines are primarily adaptable to original equipment where the engine forms an integral part of a complete assembly.



SERIES "C"

Designed for a broad range of industrial applications, Packard Series "C" engines are equipped with radiators and fans. New "free breathing" engine design contributes to its amazing operating efficiency



SERIES "B"

Series "B" engines are intended for use where cooling systems other than radiator cooling are to be used. New high economy oil control rings and precision-type main bearings contribute to its longer life.

SERIES "D"

This husky Packard is specially engineered for heavy-duty industrial applications. Series "D" engines are equipped with radiator and fan and are fully enclosed. Higher compression and streamlined manifolding make them more efficient.

ASK THE MAN WHO OWNS ONE

Write for literature

Packard Motor Car Company
Industrial Engine Dept. (Dept. P)
Detroit 32, Michigan

Please send me complete details and specifications on Packard Industrial Engines.

Name _____

Street _____

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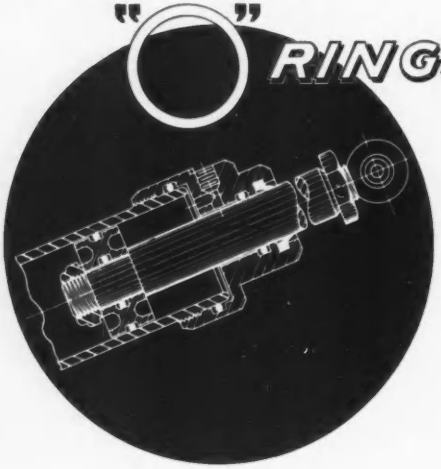
State _____

LINEAR "O" RINGS



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This compact hydraulic cylinder is only one of the outstanding examples of how LINEAR "O" rings have reduced production costs through simplification of design and installation methods.

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The use of "O" Rings in certain packing structures is covered by Christensen Pat. No. 2,180,792 under which we have paid the royalty for the installation of our rings in these structures so that the royalty is included in the purchase price of the "O" Ring.

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

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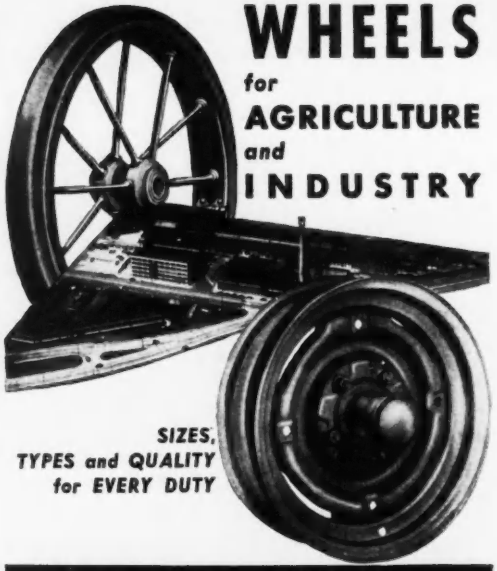

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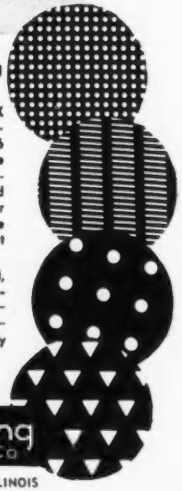

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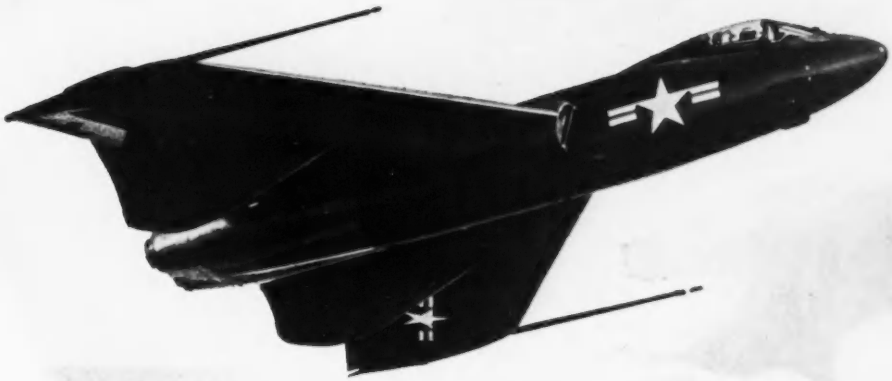
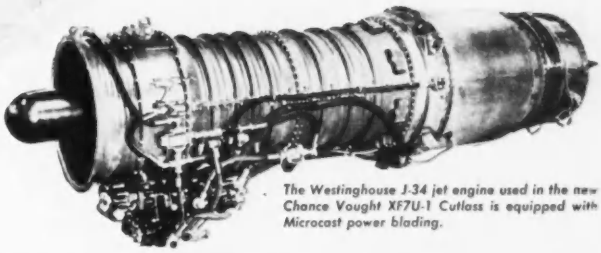


MICROCASTINGS...Basic Components in Jet Turbines



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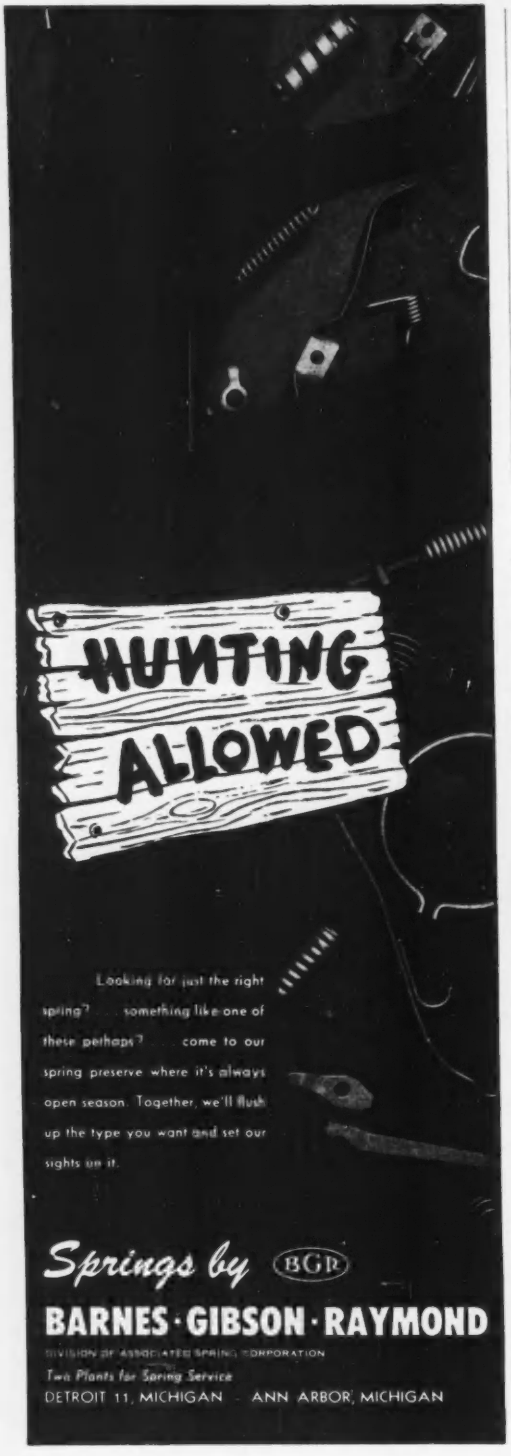

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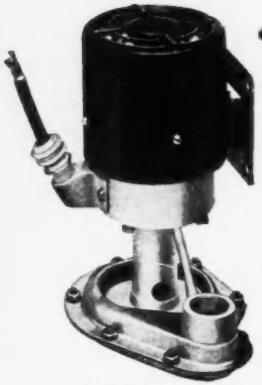

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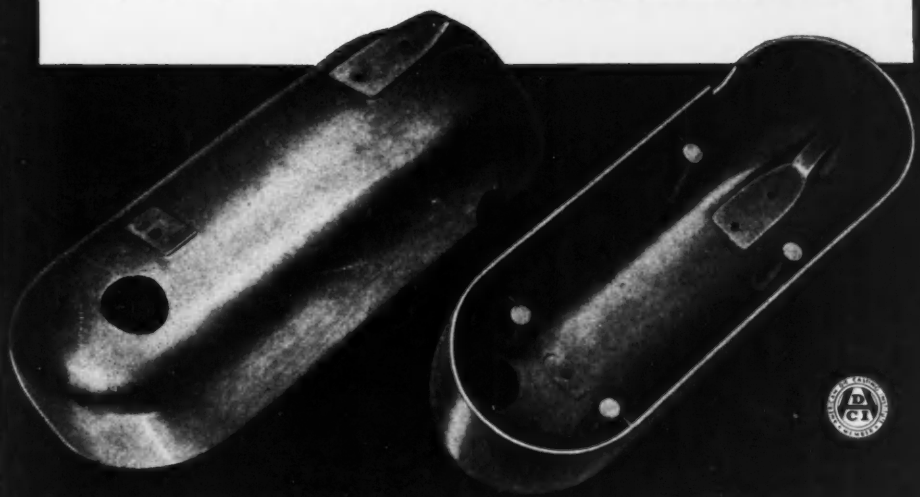

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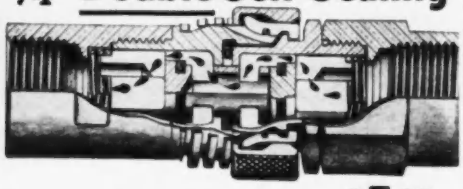

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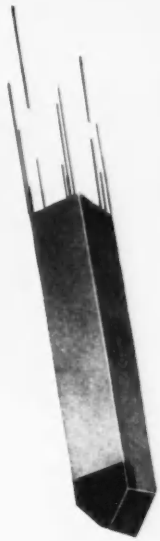

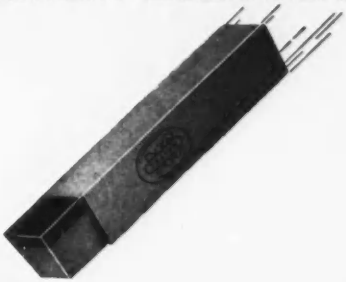

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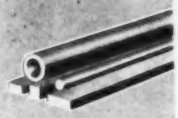

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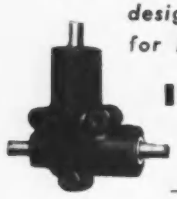

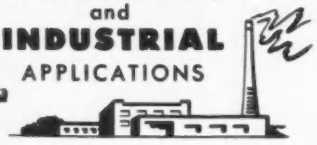

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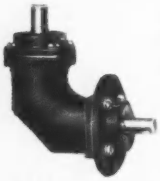

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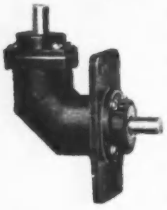

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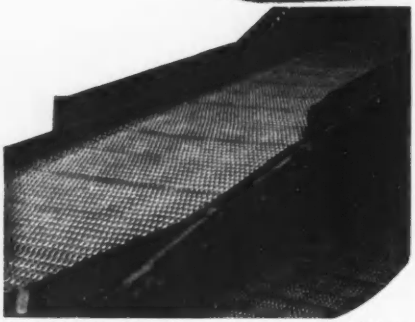

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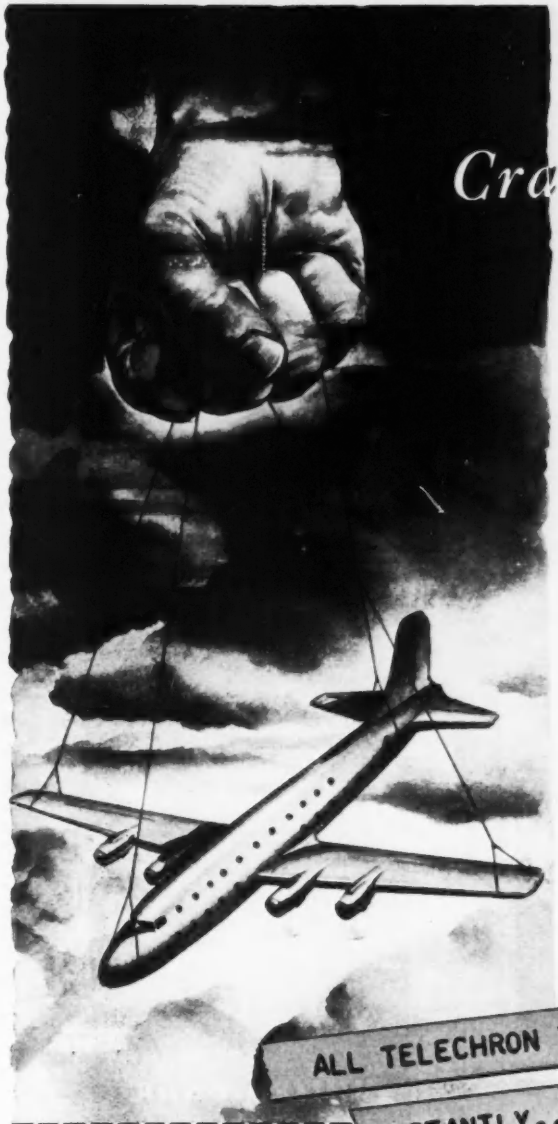

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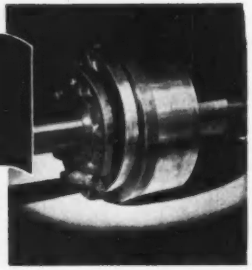

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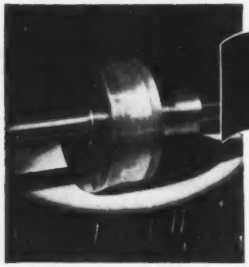
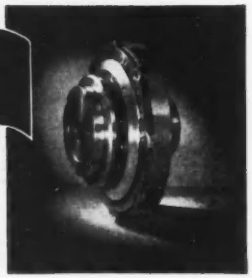


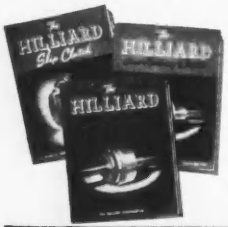
HILLIARD
OVER-RUNNING
CLUTCH

Hilliard Over-Running Clutches and Couplings are automatic in operation. They are unexcelled for automatic two-speed drives, dual drives, stand-by drives, and for allowing machinery to "coast" after drive stops. Excellent as fixed or infinitely adjustable ratchets.

HILLIARD
SLIP
CLUTCH



A reliable series of spring-loaded slip clutches and couplings. Rugged construction with ample friction surface for heavy-duty use. Outstanding for preventing overloads and shocks; for starting heavy loads; as tension drag brakes; for reeling and winding operations; and many other uses.



Hilliard's Engineering Department is ready to assist you in designing installations and in selecting the correct clutch or coupling.
Write today — 3 Hilliard Clutch Bulletins with design information. Free on request.

Clutch Makers for over 40 years

The HILLIARD Corporation
101 W. Fourth St., Elmira, N. Y.
OFFICES IN PRINCIPAL CITIES

DESIGN FOR TOMORROW

The machinery that will serve tomorrow's needs is being designed on today's drawing boards. Diefendorf gears are being specified—because they will meet every requirement for tomorrow's efficiency. All materials. All types.

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Cambridge 42, Mass.

MAKERS OF DOT FASTENERS

Four typical machine shops report

"LONGER TOOL LIFE"
"BETTER FINISH"
"FASTER OPERATION"
} WITH NEW

J&L FREE-CUTTING "E"* STEEL

J&L STEEL

Four typical examples, taken from 100 case histories, show superior machinability of J&L "E" Steel.

For 4 years before "E" Steel was publicly announced, this new, free-cutting bessemer screw stock was tried by independent machine shops throughout the metal-working industry.

More than 6,100 tons were tested in over 100 applications!

Here are quotations from 4 typical case histories:

CASE HISTORY #1 ". . . tool life increased 100% at normal speeds . . . better finish . . . shop people liked it."

CASE HISTORY #2 ". . . tool life increased up to 200% . . . uniformity of finish remained constant . . . considerably increased speeds without sacrifice to finish."

CASE HISTORY #3 ". . . tool life increased two to four times . . . we were able to tap 1" full internal pipe thread, almost impossible on regular material."

CASE HISTORY #4 ". . . new steel machines very well . . . finish excellent . . . tool life increased . . . 5 to 10% better production."

You too can get greater economies in your machining operations with new J&L free-cutting "E" Steel. "E" Steel is available in three grades: E-15, E-23 and E-33, each within the composition limits of the standard bessemer screw steels and with similar tensile properties. All standard sizes and shapes are available. For further information write for your copy of our new booklet: "J&L 'E' Steel."

Jones & Laughlin Steel Corporation
409 Jones & Laughlin Building
Pittsburgh 19, Penna.

Please send me a copy of "J&L 'E' Steel."

Name_____

Company_____

Address_____

JONES & LAUGHLIN STEEL CORPORATION

* "E" STEEL IS QUALITY-CONTROLLED FROM OUR OWN MINES THROUGH THE FINISHED PRODUCT

JUST PRINTED

Two bulletins showing how

NEW G-E MOTOR EXCHANGE PLAN

cuts machine down time

Get the story of the new time and money saving General Electric exchange plan for Tri-Clad integral-hp motors! It's an extension of the highly successful G-E fractional-hp motor exchange plan and covers most popular types of Tri-Clad open dripproof motors—one to five hp. Bulletin GEA-5189 is for motor users; Bulletin GEA-5180 is for machinery manufacturers. Write on your letterhead FOR FREE COPY: *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*

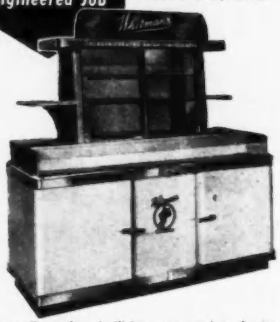
Look for this extra on the motors you buy; it means lower maintenance costs, less time lost for motor replacement.

GENERAL ELECTRIC

730-3

. . . Another SUCCESSFUL MAYSTEEL Engineered Job

A streamlined General Electric refrigerated display cabinet . . . shipped from Mayville to dealers everywhere.



Maysteel's modern facilities are geared to do the job from the rough idea right down to the finished product . . . a product that can be drop shipped direct to ultimate user, thereby saving excessive handling costs. You can count on Maysteel's creative ability and craftsmanship to turn the trick in all types of sheet metal specialties.

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Modern Plants at
Mayville, Sheboygan, Hartford, Wisconsin

Maysteel PRODUCTS

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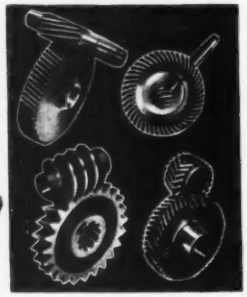
MANUFACTURERS & DESIGNERS OF METAL SPECIALTIES

FAIRFIELD

dependable source of supply for high quality

Gears!



Thirty years of uninterrupted and continuous production experience stand back of the Fairfield reputation for giving dependable, and expert service to machine builders in need of high quality, precision-made gears. At Fairfield, your gears are in the hands of specialists equipped with every modern facility for producing fine gears efficiently and economically. We believe it will pay you, as it has others, to become acquainted with the service Fairfield is rendering to manufacturers in virtually every branch of industry.

Gears Made to Order

SPIRAL BEVEL • STRAIGHT BEVEL • HYPOID
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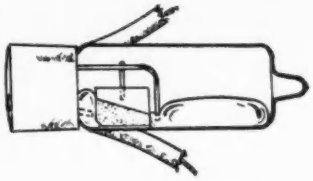
SPUR • WORMS AND WORM GEARS

FAIRFIELD for FINE GEARS

MANUFACTURING COMPANY
313 South Earl Avenue • Lafayette, Indiana

POWREX MERCURY SWITCHES

Engineered for Durability



Long life and ease of operation make POWREX switches ideal for designed-in service.

Complete range of designs and sizes up to 30 amperes.

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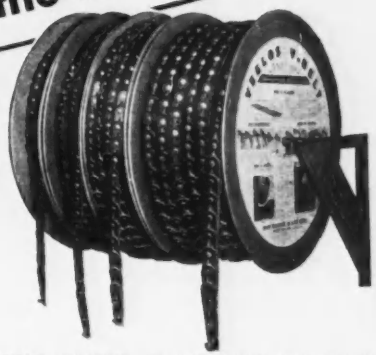
No top-heavy
v-belt inventory
with VEELOS
the link v-belt



4 reels of VEELOS replace 316 sizes of endless v-belts

● Why jam your stockroom with costly inventories of hundreds of sizes of endless v-belts when 4 reels of VEELOS will handle every v-belt job in the O, A, B and C widths? If you use only two widths of v-belts, two reels of VEELOS will be all you need.

It's a matter of record that *dollar for dollar* VEELOS gives the greatest value. Machine maintenance is kept low because uniform tension is easy to maintain. You install VEELOS *without* dismantling outboard bearings.

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- **Long Lasting**
- **Matched Belts That Stay Matched**

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THE LINK
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For All the Facts and complete engineering information, measuring and installation directions—write for your copy of the Veelos Data Book.

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ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE

Made in all standard sizes, fits all standard grooves. Packaged on reels in 100-foot lengths. Sales engineers in principal cities; over 350 distributors throughout the country. Veelos is known as VEELINK outside the United States.

DEPENDABLE! Makers of timing devices of all kinds tell us that SYNCHRON motors can be depended upon for sustained accuracy and trouble free service under all working conditions

SYNCHRON MOTORS

Never Need Oiling— Operate Efficiently In Any Position—

Motor is equipped with oil storage reservoir and patented oil feed to bearings. Rotor shaft, reduction train, and output shaft, all have double bearings to reduce vibration and assure quiet, efficient operation when mounted in any position.

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More than three million of these miniature timing motors are now in use . . . many of them for many years. Each motor is tested carefully to rigid operation standards before it leaves our factory. We make no compromise for quality!

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Send for complete engineering data on SYNCHRON synchronous, self-starting motors and time machines. Fill in, tear out, and mail this coupon:

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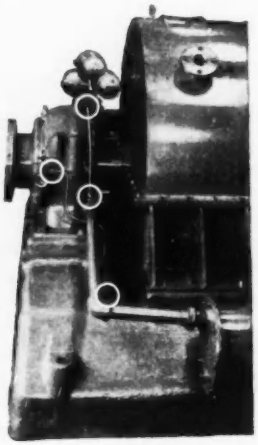
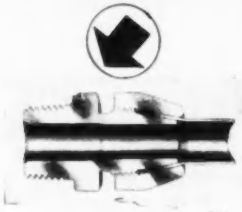
FLARED TUBE FITTINGS on Bird Continuous Coal Filters

This Bird Continuous Coal Filter dewaters up to 50 tons of fine coal per hour from a slurry at a rate of 450 gallons per minute and depends on uninterrupted lubrication for its outstanding performance. *Superseal* Flared Tube Fittings and Bundyweld tubing (welded steel tubing, copper coated) are used on the lubrication lines of this machine for three reasons. First, because of the ease of installing flexible tubing and Superseal fittings; second, because Bundyweld tubing can be easily flared in a single operation to Superseal's 10° angle; and third, because Superseal joints do not leak.





THESE *Superseal* FEATURES TELL WHY

PERMANENTLY LEAKPROOF JOINTS, unaffected by vibration and pressure.

FOR ANY TUBING, including welded steel tubing, using a single flare.

LONG, SMOOTH, TAPERED 10° FLARE on fitting and inside of self-aligning nut hold tubing securely.

NO SHEARING ACTION to injure tubing at point of flare when nut is tightened. **Tubing actually reinforced.**

REPEATED DISCONNECTIONS without injury to tubing.

PRODUCTION FLARING up to 2000 a day on inexpensive flaring machine.

STOCKED IN BRASS AND STEEL, 1/8" to 1 1/2".

Approved by Underwriters' Laboratories for all hazardous gases and liquids.

99 YEARS PIPING

GRINNELL

GRINNELL COMPANY, INC., Executive offices, Providence, R. I.
Branch offices in principal cities.

It PAYS to work with an MB Vibration Exciter

You can save time, eliminate tedious calculations, and improve your product with the help of an MB electromagnetic shaker. Note how these benefits add up in the following typical applications – just three of many uses for this quality-control and research "tool."

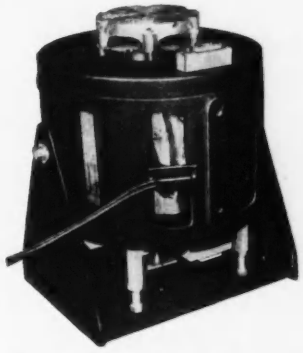
MODEL 5A VIBRATION EXCITER Delivers 5 pounds force from 20 to 1,000 c.p.s., usable to 20,000 c.p.s.

INDEFATIGABLE FATIGUE TESTER – Here is the endurance tester to show up *quickly* those faults which often result in failures under dynamic stresses. Why risk trouble reports? You can shake such parts as axles, brackets, complete assemblies, housings, castings and make improvements *before* full scale production – *before* the remedy becomes costly.

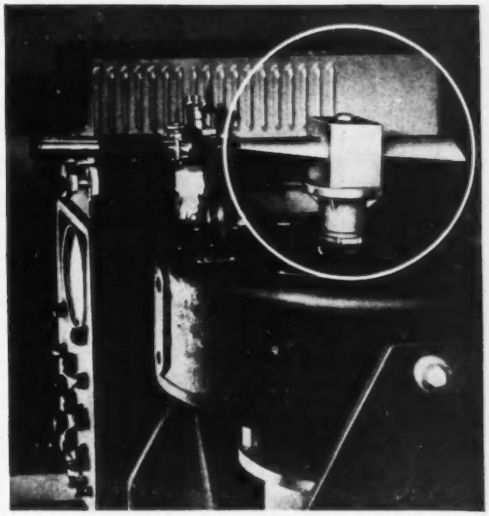
NOISE LOCATER – Operating silently, the MB Exciter reveals sources of noise in equipment of all types. Because you can "scan" a product's operating frequency range, you can put your finger right on resonant trouble areas. Less noise means more customer satisfaction.

SHAKE OUT THE "BUGS" – Electrical and sensitive components can be checked for ability to withstand severe vibratory service conditions. Reproduce the effect of years of vibration on your product within *hours!*

You'll find MB Vibration Exciters at work for many leading companies recognized for the quality of their engineering. Would you like to know how to apply one to your *own* problems? An MB engineer will be glad to show you – without obligation.



MODEL S3 VIBRATION EXCITER Delivers controlled force up to 200 pounds, in frequency range of 3 to 500 c.p.s.



Testing of small turbine blades (encircled) mounted on an MB Model C-1 Exciter which delivers 25 pounds force in range of 4 to 500 c.p.s. (and higher). Using stroboscopic lighting, resonances and deflections are studied *visually* – and any need for corrections determined quickly. A stronger, stiffer blade is sure to result.

DO YOU HAVE OUR NEW BULLETIN ON FILE?
It contains helpful design data on vibration control, plus more information on the line of MB Exciters. Write for your copy today. Ask for bulletin No 410-46.

THE MB MANUFACTURING COMPANY, Inc.
1060 State St., New Haven 11, Conn.

universal joint trouble?

Replace them quickly and easily . . . . . with CURTIS UNIVERSAL JOINTS

The Curtis "Telltale" lock ring makes disassembly and reassembly of universal joint connections a simple and economical operation. No dismantling of shafts — a minimum of "down time" required for change.

Time-proven under many different conditions and applications, Curtis Universal Joints have conclusively shown their superiority — in the field and in laboratory tests.

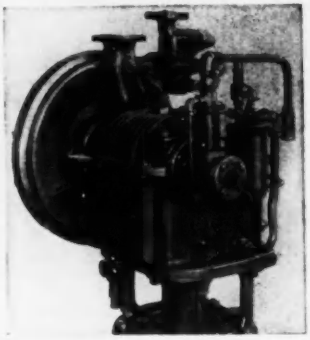
Because of their proven quality, manufacturers are specifying "Curtis" more and more. They have found it pays to use "Curtis" as a "standard" in their original equipment. Their customers are better satisfied — fewer replacements are needed, and they are assured of furnishing the best by every test.

Specify the best for original or replacement use — specify Curtis.

"Telltale" Lock Ring readily visible — shows joint is securely locked.

Write Dept. B-2

CURTIS UNIVERSAL JOINT CO. INC. SPRINGFIELD MASS.



De Laval-IMO lubrication and governor oil pump direct connected to high speed turbine shaft.

Pumps oil at 5800 rpm

De Laval-IMO pumps can be direct connected to high speed shafts. No space consuming gear reductions are necessary. Pump capacity is high compared to its size and weight.

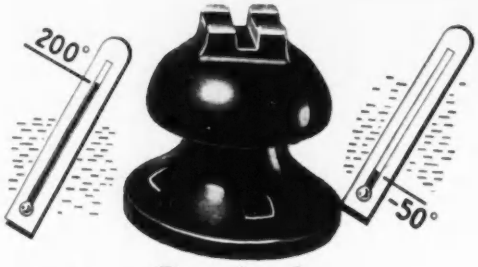
Investigate the IMO if you need a dependable, high speed, pulsation-free pump for lubricating oils, fuel oils, hydraulic control fluids or viscous liquids.

Ask for Catalog L-21NT-C

I-154

IMO MARINE I MOVE OIL

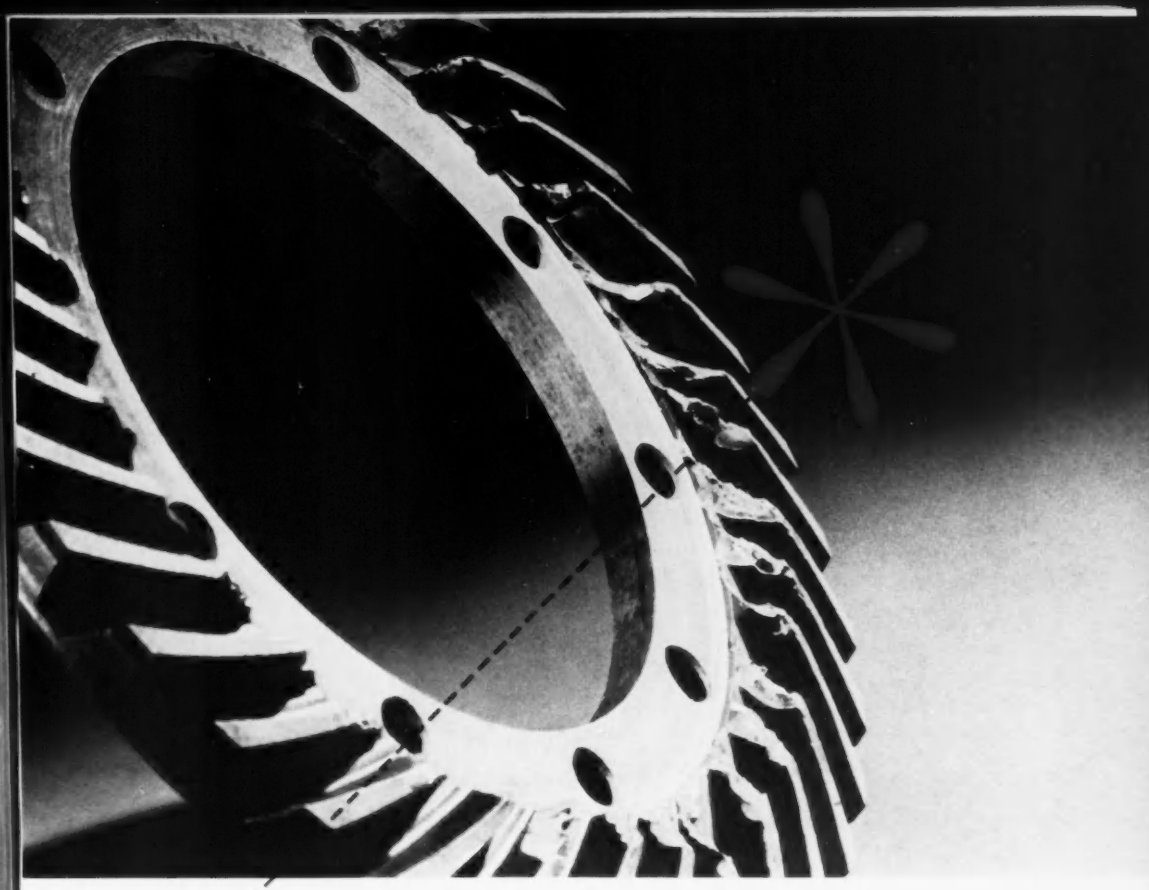
IMO PUMP DIVISION of the DE LAVAL STEAM TURBINE CO. TRENTON 2, NEW JERSEY



Ready for Temperature Extremes

Extremes or sudden changes of temperature have no effect on Universal Porcelain Insulators. In tropic sun or arctic cold they stand up. Because they are porcelain, they have high dielectric strength. They withstand shock and strain. They resist heat, moisture, fumes and most acids. They do not carbonize nor corrode under long years of service. A Universal engineer will be glad to assist in adapting these advantages to your insulator requirements. Just phone, wire or write. No obligation.

THE UNIVERSAL CLAY PRODUCTS CO.
1545 EAST FIRST STREET SANDUSKY, OHIO
TRADE MARK



The Inside Story of a Pinched Penny

THERE is no economy in a cheap gear. On the contrary, a pinched penny may purchase untold expense—plus headaches without number.

That is why we specialize in gears—"Double Diamonds"—that possess *true* economy. Economy expressed in terms of lowest *final cost*—including installation *and* performance.

It takes a little more time to make "Double Diamonds"—and considerably more experience, care and skill. But when they're done, we're proud of them. And because they contribute so substantially to the life, the performance, and the continued efficiency of your product, you'll be proud of them, too.

Manufacturers interested in gears that are built to show lowest final cost—who have an eye for long-run economy—are requested to write for information.

DOUBLE DIAMOND
TRADE MARK
GEARS

Made by
Automotive Gear Works, Inc.
RICHMOND, INDIANA

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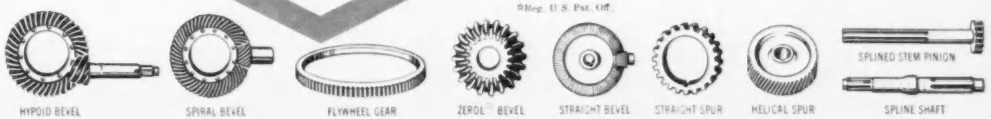

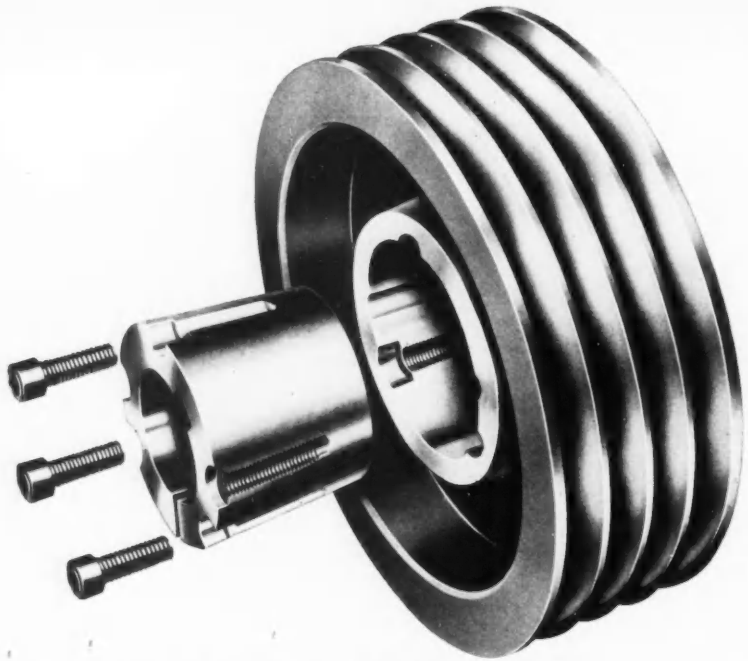

The new idea in V-Belt Sheaves
that saves you time and money!
Proved in over 3/4 million installations!

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1 No flange. No collar. It's different.

2 Easy on — easy off.

3 Just tighten the screws that wedge the bushing. Simple, isn't it?

4 Always a perfect fit on shaft — tight as "shrunk-on."

5 Complete range of sizes. A, B, C and D grooves, in stock.

6 Try it—and you'll standardize on it!

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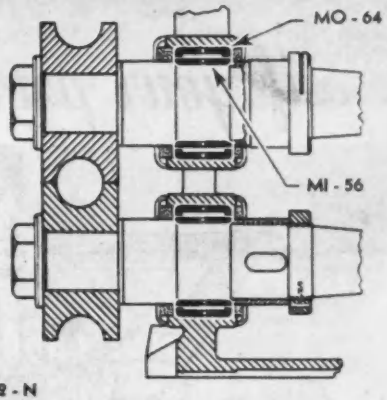
CALL THE TRANSMISSIONEER, your local Dodge Distributor, for information on new and better methods of transmitting power. Look for his name under "Power Transmission Equipment" in your classified telephone book.

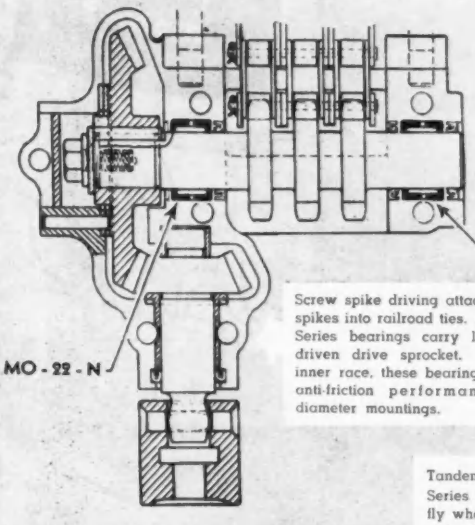
DODGE
of Mishawaka, Ind.

NAME PLATES

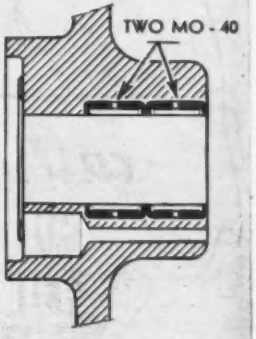
FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS

In this continuous tube welding machine, MULTIROL SE Series bearings carry the tube forming load as journal bearings. To support the heavy load, shafts are kept large, but journal dimensions are held to the minimum — reduces cost.

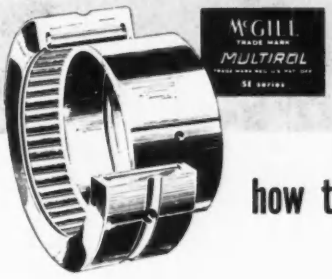




Screw spike driving attachment screws spikes into railroad ties. MULTIROL SE Series bearings carry load of chain driven drive sprocket. Used without inner race, these bearings provide full anti-friction performance in small diameter mountings.



Tandem mounting of MULTIROL SE Series bearings on a punch press fly wheel. Bearings are mounted in pairs for even distribution of extra heavy load and easily carry impact of shock load every time clutch is engaged. Shaft serves as inner race permitting more compact mounting.



how to anti-frictionize for improved performance

THE MULTIROL WAY

The efficiency of any machine can be raised when plain friction bushings are replaced with MULTIROL SE Series full type roller bearings. Speeds are easily increased and accuracy improved over a longer expected bearing life.

The MULTIROL Way requires less maintenance because lubrication can be provided through either the shaft or housing — oil holes and channels in both outer and inner — no need for constant oiling — no danger of dry journals when lubrication is temporarily neglected.

Costs less too. Ordinarily large housings can be reduced to accommodate the MULTIROL Bearing minimum OD for a given shaft size and load capacity. Remember also that eliminating friction saves on power imput.

MULTIROL SE Series bearings are anti-frictionizing machines in all industries. The above drawings illustrate typical examples of improved bearing applications. We will gladly make engineering recommendations for you. Write today for helpful MULTIROL Bearing literature.

Address McGill Manufacturing Co., Inc., 201 N. Lafayette Street, Valparaiso, Indiana, for your copy of MULTIROL Bulletin SE-48.

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TRADE MARK
precision bearings

if your product

calls for

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Coto-Coil engineers are here to help you solve your coil problems. Whatever your requirements, Coto-Coil quality always assures the "best for the least".

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COIL SPECIALISTS SINCE 1917
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you'll find it easier, faster if you...

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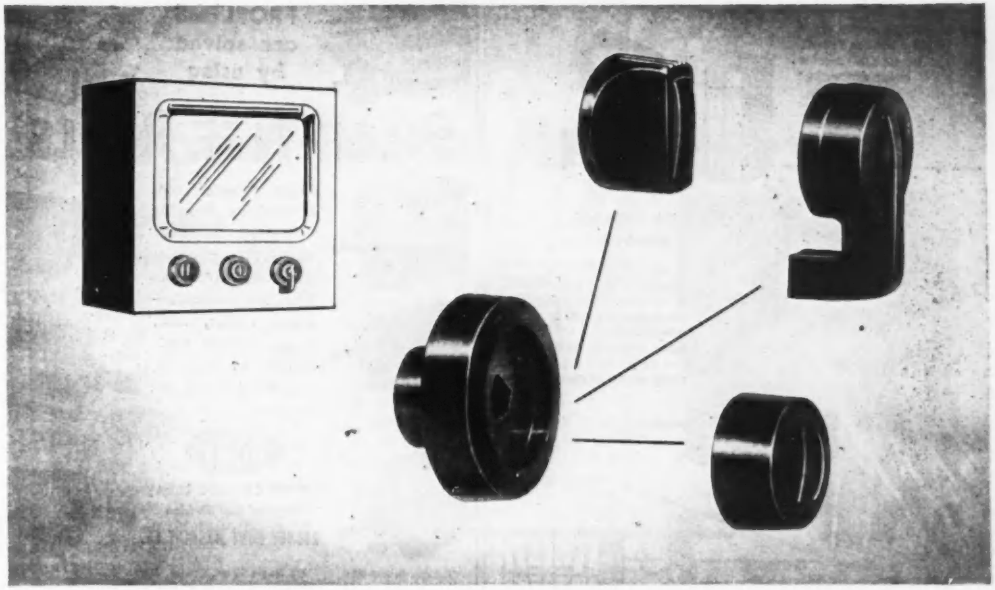

Standard TV Dual Control Knobs

HERE'S AN END to TV knob design problems and the high cost of custom knobs, too. Here's the Kurz-Kasch line of standard plastic dual control knobs—standardized for universal fit —standardized for dependable use— standardized for economy. With Kurz-Kasch TV knobs, you can begin to eliminate some of your costly assembly variables.

Because warp and cold-flow are best eliminated by thermo-setting materials, these knobs are compression-moulded for complaint-proof long life. Like all Kurz-Kasch standard parts, they are produced in a variety of dimensions, colors, finishes and decorative designs.

TV Dual Control Knobs are the newest additions to the Kurz-Kasch Standard Parts Line — long considered America's foremost source of standard plastic knobs and handles. For complete specification and dimensional data, write for Kurz-Kasch Specification Sheet No. 432. Or ask for new catalog 103A listing our complete line of TV Knobs, Radio Knobs, Instrument Knobs and Control Balls. No obligation.

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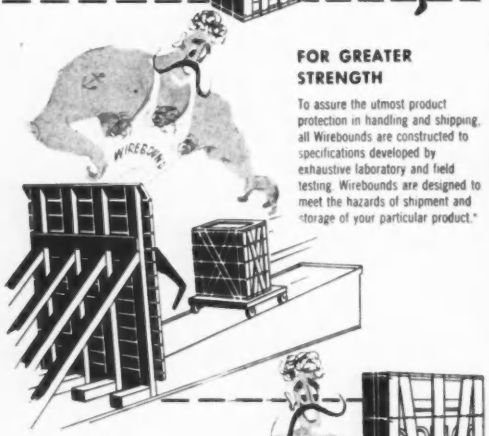

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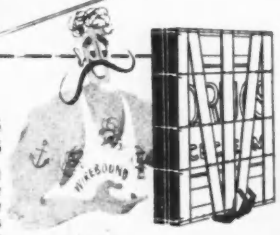

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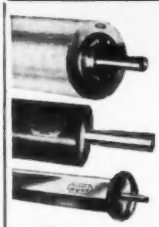

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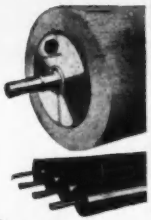

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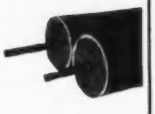

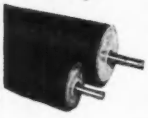

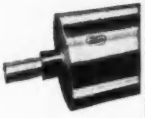

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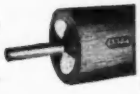

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JOHNSON BRONZE
SLEEVE BEARING DATA

Bearing TYPES

JOHNSON BRONZE
SLEEVE BEARING DATA

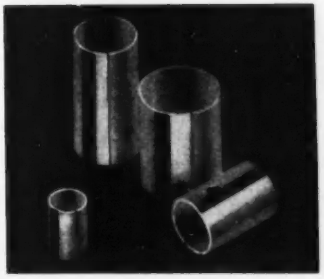
Sheet Metal Bearings-3

Steel-Back Babbitt-Lined Bearings

THIS TYPE of Sleeve Bearing is usually referred to as "laminated". This because two separate metals are firmly bonded together. In the automotive industry, the largest user, they are sometimes referred to as "Slip-in" bearings.

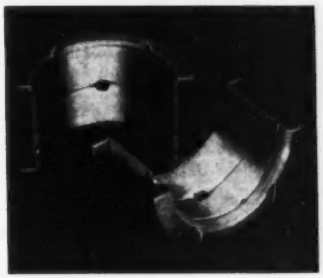
The first step in the manufacturing process is the coating of the steel strip—S.A.E. 1010—with either tin-base or lead-base babbitt . . . as the application may require. This is a continuous process with exact temperature control and necessary precautions to prevent oxidation. Extreme care must be exercised in this operation in order to secure a perfect, durable and lasting bond of the two metals. Next, the strip is brought to the desired thickness. The balance of the manufacturing procedure is essentially the same as in other types of sheet metal bearings . . . stamping, forming and finishing to precise size. Steel and babbitt bearings are available in a wide range of sizes, plain or flanged, half bearings or cylindrical. Oil grooves, slots or holes can be incorporated during stamping operation.

Several standard thicknesses of steel are used, depending on the nature of the application. For example: .036, .050, .060, .070, .080, .090 and .100. In general applications the thickness of the babbitt will run from .015 to .020. While on precision-type bearings it is held to .002 to .005.



The selection of the babbitt depends quite naturally on the bearing application. Lead-base babbitt is much more economical than tin-base and in certain alloys will provide a higher load carrying capacity. While tin-base is more expensive it has better corrosion resistant properties and a higher fatigue strength. Both materials have performed very well in automotive, diesel and electric motor applications, with a slight preference for tin-base babbitt in main and connecting rod bearings.

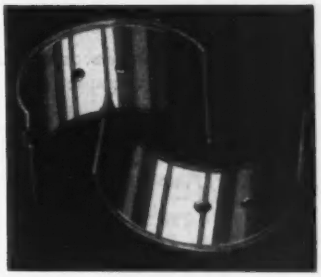
While steel-backed babbitt-lined bearings are best suited for light to moderate loads with high speed, there is a definite relation between the thickness of the babbitt and the



load carrying capacity of the bearing. A babbitt thickness of .020 has a generally rated load capacity of 1500 pounds per square inch whereas by holding the babbitt to .002 to .007 increases the capacity up to 2000 pounds per square inch. This results in longer bearing life.

When babbitt-lined bearings are used within the range of their load capacity they are generally considered the best bearings available. They can be used with steel shafts of practically any hardness. It must be remembered, however, that as the hardness of the shaft increases, the resistance to wear increases.

The method of installing steel and babbitt is practically the same as bronze and steel or bronze sheet metal. We recommend that they be



line reamed or bored in assembly. Burnishing should be avoided if possible.

Main bearings are usually produced on specially designed equipment to keep within a tolerance of .0005 and .0005. This accuracy permits any two halves to make one complete bearing, thus simplifying installation.

Some of the most desirable qualities of steel and babbitt bearings are:

1. Good wettability with lubricants.
2. High corrosion resistance to most oils at operating temperatures.
3. High embeddability.
4. Good conformability.
5. Work well with soft shafts.

•

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

This bearing data sheet is but one of a series. You can get the complete set by writing to—

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SLEEVE BEARING HEADQUARTERS
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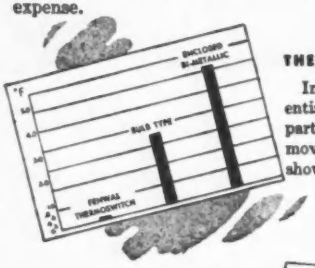
Instead of a costly, elaborate indicator-controller installation, a manufacturer selected three compact, easily installed Fenwal THERMOSWITCH* units for use with simple equipment designed with the assistance of a Fenwal engineer. Accurate, rugged and with contacts fully enclosed by the temperature-sensitive shell, these Fenwal precision thermostats are giving complete satisfaction . . . at a tremendous saving in original cost and maintenance expense.



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In conventional temperature controls, differential is the result of backlash caused by moving parts. The THERMOSWITCH*, with no such moving parts, has a negligible differential as shown in the chart.

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When you deal with INDIANA, it's like adding the finest facilities as a department in your own organization—pattern making; casting; sintering; heat treating; finishing; magnetizing—plus technical knowledge with experience and foresight. You get helpful aid in designing to cut costs . . . uniform high energy for every application . . . magnets that are *right*. It pays to call in INDIANA. Do it now!

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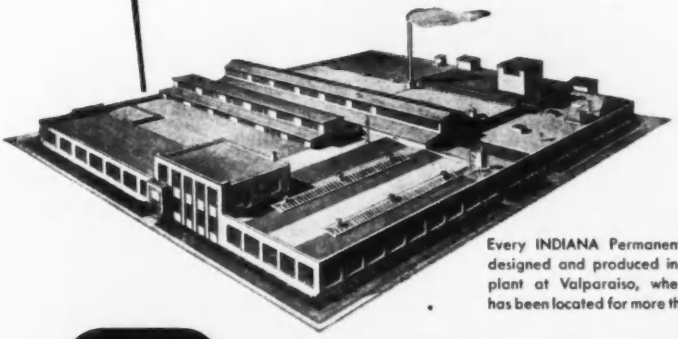

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STAINLESS STEEL FASTENINGS DO THE JOB Better

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Appliance Window Panel. Supplied to top home appliance manufacturers. Made of McKee Glasbake brand boro-silicate glass. Provides visibility, sales appeal. Resists hard usage, thermal shock, etching action of soaps and detergents.

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BY BARRY

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Large machine tool base shown here utilizes high damping capacity of Gray Iron

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- Durability
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Write for free booklet, "GRAY IRON—Its Mechanical and Engineering Characteristics, and Details for Designing Cast Components".

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Gray Iron has exceptionally high damping capacity, higher than any of the other common engineering materials . . . up to *ten times* that of any other ferrous metal.

The practical usefulness, therefore, of a part subject to vibration stresses, may be *greater when it is made of Gray Iron* than when it is made of what might commonly be regarded as a much stronger material, but which has *low damping capacity.*

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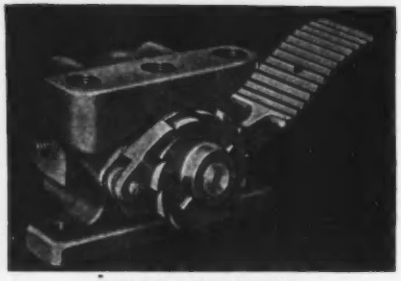
NEW Foot Valves by NOPAK



NOPAK Model "F" Foot Valve

NOPAK Model "R" Foot Valve

These new Model "F" and Model "R" Foot Valves embody a number of installation and operating advantages which include:

- Eliminating the internal exhaust core in the valve disc.
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- Reduced possibility of plugged passages.
- "Exhaust" port located at top of valve, between the two "cylinder" ports, simplifies piping.
- Reduced overall height.
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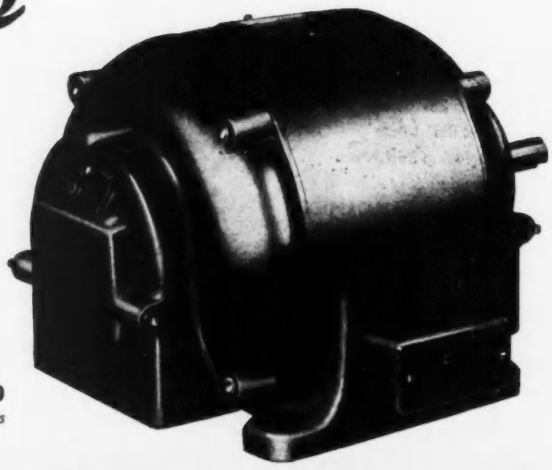

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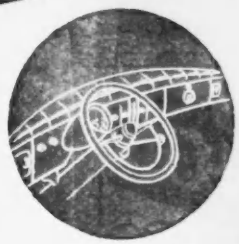
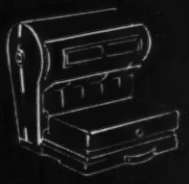
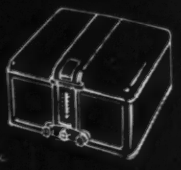
ALL *Peerless Motors* ARE "PEERLESS REGISTERED"

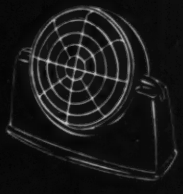


Many of America's best-known manufacturers call on General American to develop and produce successful plastics parts and products. They depend on General American's many years of precision production experience. They benefit from the use of the most modern equipment available—2 oz. to 48 oz. injection presses and 100 ton to 2000 ton (71" x 74" platen areas) compression presses.

When plastics can be used, General American can serve you from engineering to delivery.







A FEW OF THE ITEMS GENERAL AMERICAN MOLDS FOR MANY INDUSTRIES:

Agitators for washing machines
Air Circulators
Airline Trays
Brush Holders
Business Machine Housings
Chairs
Cheese Containers
Contact Blocks
Control Panels
Cosmetic Cases
Dinnerware
Electric Iron Handles
Escutcheons
Fan Housings
Fishing Tackle Boxes
Freezer Lids
Instrument Panels
Key Holders
Luggage Trays
Machine Wheels
Radio Cabinets
Refrigerator baffle assemblies, breaker strips, coil door covers, crispers, drip pans
Record Players
Salt & Pepper Shakers
Scale Housings
Silverware Trays
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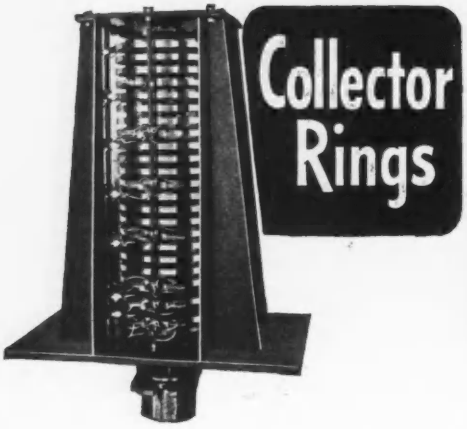

WELCO Collector Rings are made in all sizes to carry currents of 5 to 200 amperes. Two to twelve rings can be furnished on one stub complete with brush holders, brushes, studs for supporting the brush holders and stud rings. The collector rings can be assembled as a unit on one hollow tube with threads on one end and insulation bushing on the opposite end. The brush holders carrying the current are made of brass. The collector rings are made of hard bronze material. Bakelite insulation is used.

Welco Collector Rings are custom-built to fit the special design and functional requirements of your machines or equipment. A limited number of standard types are available. Send us your blueprints and we will design for you the collector rings that are functionally correct.

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BULLETIN NO. 6
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For maximum sealing effectiveness in minimum space, you can't beat "Sealol". Its balanced-pressure design saves valuable axial length . . . and helps reduce the overall size of your product. "Sealol" handles an unusually wide range of conditions: shaft speeds even in excess of 10,000 FPM, fluid pressures in excess of 1000 psi, and temperatures as high as 500° F. — depending on overall operating requirements. Write today for engineering recommendations.

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ANY SHAPE · ANY MATERIAL · COMPLETE FACILITIES
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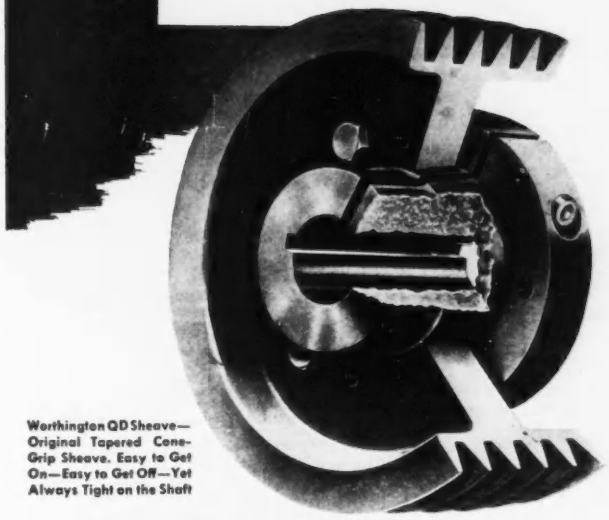
THE GOOD RIGHT HAND OF INDUSTRY

Tapered...

to take an easy fit



Worthington QD Sheave—Original Tapered Cone-Grip Sheave. Easy to Get On—Easy to Get Off—Yet Always Tight on the Shaft

The tapered mating of the two-piece QD Sheave makes Worthington's Multi-V-Drive an attractive sales point for your equipment.

It's the easiest sheave to install because the lightweight split hub goes on first . . . is locked in place . . . then the tapered-bore rim slides over the tapered-cone hub . . . is pulled up by full-sized bolts.

Easy as this is, the QD *stays tight* on the shaft. The cone-friction grip on the hub produces a positive press fit on the shaft. The QD clamps the shaft tighter than any other sheave on the market!

For Balanced Drive Performance

Specify Worthington Multi-V-Drives, with QD Sheaves and Worthington-Goodyear EC V-Belts. Each strand in the belt carries its equal share of the belt load, as each belt carries its full share of the drive load. (Goodyear EC Cord or Steel Cable V-Belts are used exclusively in Worthington Multi-V-Drives.)

Complete Range of Stock Sizes —Prompt Shipment

853 listed stock sizes in "A", "B", "C", and "D" sections, fhp to 200 hp . . . 332 listed stock sizes of EC Cord V-belts. *Send coupon for latest Worthington QD Sheave bulletin.*

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WORTHINGTON PUMP AND MACHINERY CORPORATION

MULTI-V-DRIVE SALES DIVISION—BUFFALO, N. Y.

The Good Right Hand of Industry

POWER TRANSMISSION: sheaves, V-belts, variable speed drives

PUMPS: centrifugal, power, rotary, steam

AIR COMPRESSORS: water-cooled, air-cooled

Worthington Pump & Machinery Corporation
Multi-V-Drive Sales Division, Dept. MVP 97
Buffalo, N. Y.

Send latest bulletin on Worthington Multi-V-Drives.

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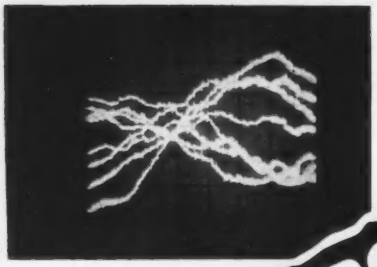
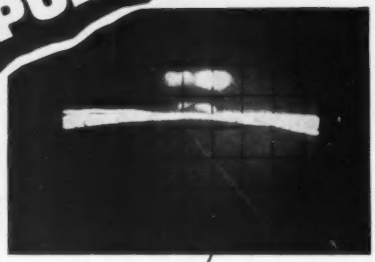


BEFORE INSTALLATION OF ACCUMULATOR
Horizontal graduations equal 50 psi and full sweep equals 0.3 seconds. Without accumulator the maximum pressure swing of the surging fluid is 350 psi.

HOW TO IRON OUT PUMP PULSATIONS



AFTER INSTALLATION OF ACCUMULATOR
Same installation with accumulator in system, the maximum pressure swing was reduced to 20 psi.

Pressure surges and pump pulsations are the two most common causes of pipe lines and hydraulic system failures. Surges and pulsations, however, can be greatly minimized or eliminated by installing a Greer Accumulator in the system. A simple "T" connection is all that is necessary to install it in any existing or newly designed circuit.

The "Before" and "After" photographs above give vivid proof of the effect of accumulators in hydraulic systems. A hydrauliscope and camera attachment were used to photograph the surges and pulsations of an actual pumping circuit. The "Before" picture shows the high degree of pulsations in the line not using an accumulator. The "After" picture shows how these surges and pulsations were effectively ironed out and virtually eliminated by the use of an accumulator.

Similar tests can be performed in your own system to demonstrate the effectiveness of a Greer Accumulator.

A request for further information on your company letterhead will bring an immediate reply. Write today!

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HANDBOOK of PATENTS

By Harry A. Toulmin, Jr., J.D., Litt.D., LL.D.
Senior Member of Toulmin & Toulmin; Member of Bar of Supreme Court of United States and various Federal Courts

HERE, at last, is a clear, accurate handbook that explains in simple, familiar terms, every step in the procedure and practice of present-day patent law. It contains every aid the layman needs to deal safely and intelligently with any situation involving patents.

The great chapter on the special types of patents is especially valuable for its detailed treatment and illuminating examples of twelve distinct types of patents, with the differences in details of treatment that result from their individual characteristics. The same systematic, step-by-step procedure has been utilized by the author in his chapters on drafting and prosecuting a patent application, on keeping patent records, on investigating patent records, etc., etc.

The appendix contains a vast fund of useful practical information including in full, the Rules of Practice in the United States Patent Office, as well as all the forms used in patent work. The comparative provisions on which patent practice is based, and indices of patent laws and the Rules of Practice.

Written By an Outstanding Authority

THE AUTHOR of this book is exceptionally well qualified to present patent law in terms that are most intelligible to the layman and most readily applicable to his needs, whether he is an engineer, technician or businessman. Mr. Toulmin, in his association for many years with the firm of Toulmin & Toulmin, has had the most diversified experience in patent practice, not only in the Patent Office, but in many courts, including the United States Supreme Court.

He brings to the patent field a viewpoint that is sympathetic to engineering problems, since he is the head of a commercial research laboratory. He has a broad writing background, as the author of books on various phases of patent law, and as the writer of many informative articles on practice and research. In this current book, the "Handbook of Patents", Mr. Toulmin has at last provided a complete working manual for the needs of everyone, professional and non-professional alike, whose work relates in many ways to invention and patents.

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These 5 Big Advantages of the Garlock KLOZURE

1. The sealing element is tough and durable
2. It stays firm and resilient
3. It resists oil and heat
4. It is extremely sensitive and flexible
5. Garlock KLOZURES are made in many models and in a complete range of sizes*

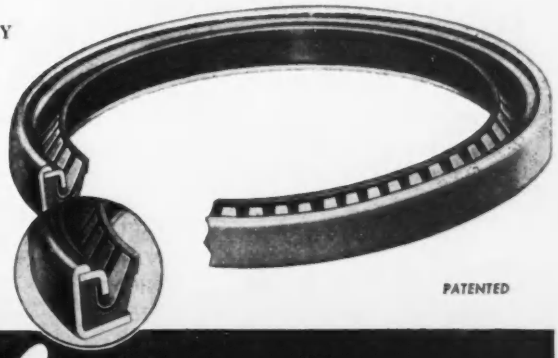
*Including Metric O.D. to fit bearing manufacturers' standard bores.

The sealing element in the Garlock KLOZURE Oil Seal is a special synthetic composition developed by Garlock to resist oil and heat. It is unaffected by temperatures up to 250° F. Also it is remarkably tough and durable—stays firm and resilient even after long service.

The unique tempered spring used in the new Models 53 and 63 KLOZURE is extremely sensitive and flexible. Each finger or lug is alive and each delivers independently its required light pressure to the tip of the sealing element.

Write for KLOZURE *catalog!*

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK
In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.



PATENTED

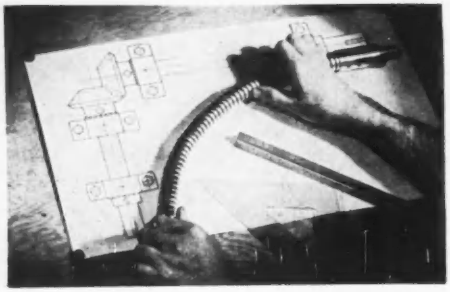
Illustration shows Model 53 KLOZURE which is produced in a range of sizes for 3" to 10" shafts. Model 63 KLOZURES, employing the same engineering principles but differing in details of design, are made in a range of sizes from ¼" to and including 3" shafts.

GARLOCK Klozure* OIL SEAL

*REG. U. S. PAT. OFF.

Design Engineers!

Power Transmission Problems SOLVED SIMPLY WITH STOW Flexible Shafts



● **STOW FLEXIBLE SHAFTS** simplify intricate power transmission problems by eliminating complex gearing with its close tolerance and alignment difficulties.

● **STOW FLEXIBLE SHAFTS** provide savings . . . increase design efficiency and eliminate hazards of exposed shaft assemblies.

● **WRITE TODAY FOR YOUR COPY OF STOW'S NEW BOOK ON FLEXIBLE SHAFTING** (included in Sweet's 1949 File for Production Designers). LEARN HOW STOW FLEXIBLE SHAFTS HAVE BEEN SOLVING POWER TRANSMISSION PROBLEMS SINCE 1875.

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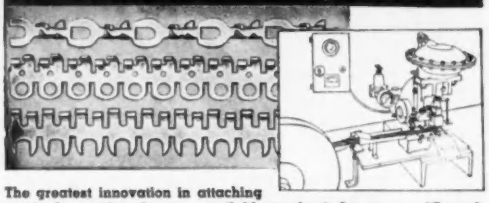

The greatest innovation in attaching terminals to wires is now available to the industry . . . "Pre-soldered" TANDEM TERMINALS! Made in various sizes and types, these remarkable, production-proved terminals (supplied on reels) can be applied at rates up to 1200 per hour by a new Terminal Attaching Machine that cuts off, clinches and solders terminals in one instantaneous operation. Handling of loose terminals, solder and flux are eliminated to reduce costs and boost production on long runs. Standard types available. Send for detailed information, enclose sample of wire and terminal now used. Address Dept. B.

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We also make SMALL METAL STAMPINGS Exact to Customer's Prints. Modern Plant and Equipment. Moderate Die Charges. Precision Work. Prompt Service.

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A Mercury Clutch will reduce starting current demands and provide positive protection against motor damage, blown fuses, and resulting fire hazards due to extreme low voltage conditions. Write for catalog.

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On a gasoline engine a Mercury Clutch allows load-free starting and no-load idling. It eliminates stalling. Write for catalog.

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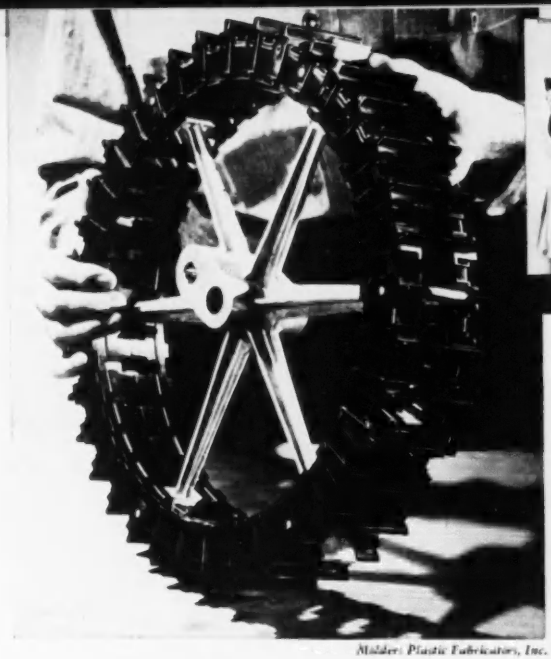


Molder: Plastic Fabricators, Inc.

BAKELITE NEWS

NO. 7

NOTES FROM BAKELITE CORPORATION ON BETTER, FASTER, LOWER COST PRODUCTION WITH "BAKELITE" PLASTICS

$313 Savings Per Machine Through use of BAKELITE Phenolics!

❶ Here's how one manufacturer obtained a better product at considerably lower cost. BAKELITE Phenolic Plastics replaced die-cast metal for the four dispensing rings of the new "Kenro" ice cream vending machine. Direct savings totalled $304 for the four rings. Additional savings of $9.12 per machine were obtained by replacing eight shaft bushings of soft metal that cost $1.20 each, with BAKELITE Phenolic molded bushings costing only 6¢ each. The plastic parts contributed further indirect savings by reducing the weight of the machine 30 pounds, thereby lowering shipping costs, and by the elimination of several machining and finishing operations.

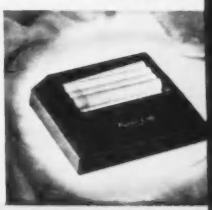
It may pay you, too, to redesign your products or component parts around BAKELITE Phenolic Plastics.

PACKAGES that Sell and Keep on SELLING

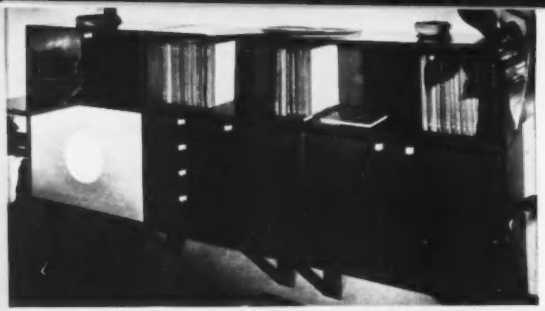
❷ Everyone gains from the new BAKELITE Styrene Plastic packages designed by Walter Dorwin Teague for Kreisler-Craft men's jewelry. Not only do these packages sell goods, but they continue to build goodwill through their re-use value to the consumer. They appeal to the retailer because they can be converted instantly into eye-catching displays, or can be nested on dealers' shelves for mass display effect. Above all the use of BAKELITE Styrene Plastics enabled Kreisler to develop a package with exceptional quality appeal, at a cost that was well within the normal margin allotted for packaging these popular priced jewelry items.

BAKELITE Styrene Plastics are a "natural" for packaging. They are light, strong, lustrous, available in an unlimited range of colors, transparent, translucent, and opaque. They are rapidly and inexpensively fabricated by injection molding into intricate shapes, and give fine, clear cut reproductions of mold details. Let us show you how to package profitably with plastics.

Molders: Cowan-Boyden Corp., General Electric Co.



MORE BAKELITE NEWS ON NEXT PAGE



Bakelite

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BAKELITE CORPORATION
Unit of Union Carbide and Carbon Corporation UCC
30 East 42nd Street, New York 17, N.Y.

Design Changes Are Easy with Versatile, Adaptable Plastics!

Check coupon below for information on specific subjects illustrated. For general information, write for copy of Booklet G-8, "A Simplified Guide to BAKELITE and VINYLITE Plastics."

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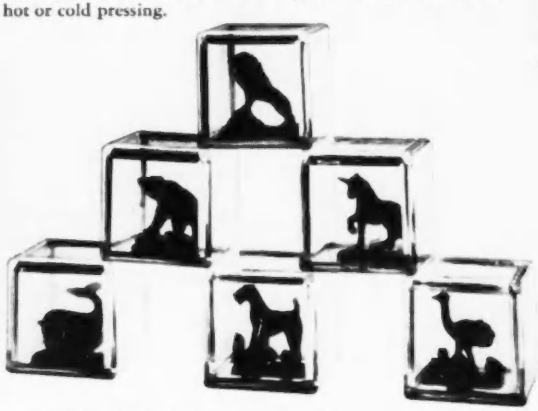
LOWEST COST Resin Glue for Top-Quality Furniture

❸ Heard about BSC? It stands for built-in storage components—a progressive new idea in furniture design and construction that bridges the gap between portable furniture and prefabricated storage wall systems. Built by Herman Miller Furniture Company from designs by George Nelson, the BSC furniture units illustrated owe their durability to good design plus BAKELITE BCU-22 Urea Resin Glue. The glue is employed in the manufacture of the fine plywood panels, and also in assembling the various furniture components. But the best news of all is that these quality bonds are obtained at the lowest possible cost because BCU-22 is the most economical of all synthetic resin adhesives available today. It is suitable for either hot or cold pressing.



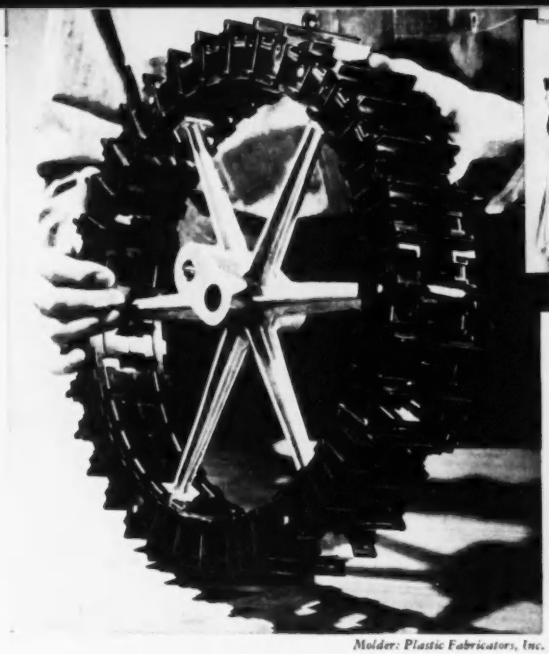
ORIGINALITY Pays Off With BAKELITE Styrene Plastics

❹ Originality of design applied to colorful strong, BAKELITE Styrene Plastics has brought wide acclaim to these unique "Kusan" toys. Illustrated are the basic transparent blocks containing sealed-in animals and other figures that appeal to little tots. These blocks can be assembled in various ways to provide roller-pull toys, rattles, and other equally intriguing play items. They are strong enough to take a beating, are smooth, washable, and non-shattering. They are designed and molded by Kusan, Inc., Plastics Division, who produce a great variety of Styrene Plastic toys in transparent, translucent and opaque effects.

GOOD NEWS for Product Finishing Departments

❺ Latest advances in protective coatings are color-stable, white and light-tinted enamels based on BAKELITE C-10 Resins. For example, Resin BJS-502 can be formulated into enamels that exhibit several unique qualities of particular importance to product finishing technologists. A single coat, either dipped on or sprayed on, provides high gloss and appearance equivalent to multiple coats of lacquer, yet the enamel air dries tack free in 5 to 15 minutes. When finishing schedules call for additional coats, the enamels can be recoated any time from 1 to 96 hours or later without lifting, when the recommended solvent balance is followed.

These coatings can also be baked rapidly to produce hard tough films with excellent color retention. Use the handy coupon to obtain further information.



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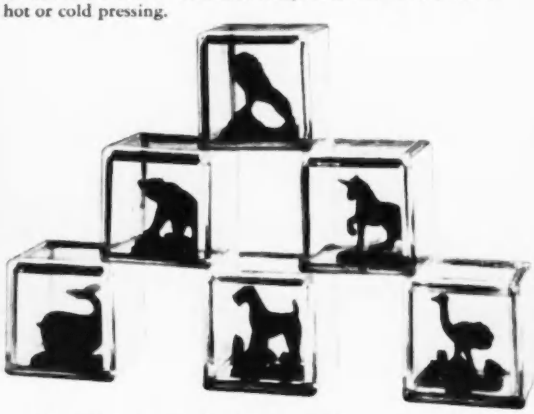

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on applications with FAN BLADES mounted on the motor shaft,

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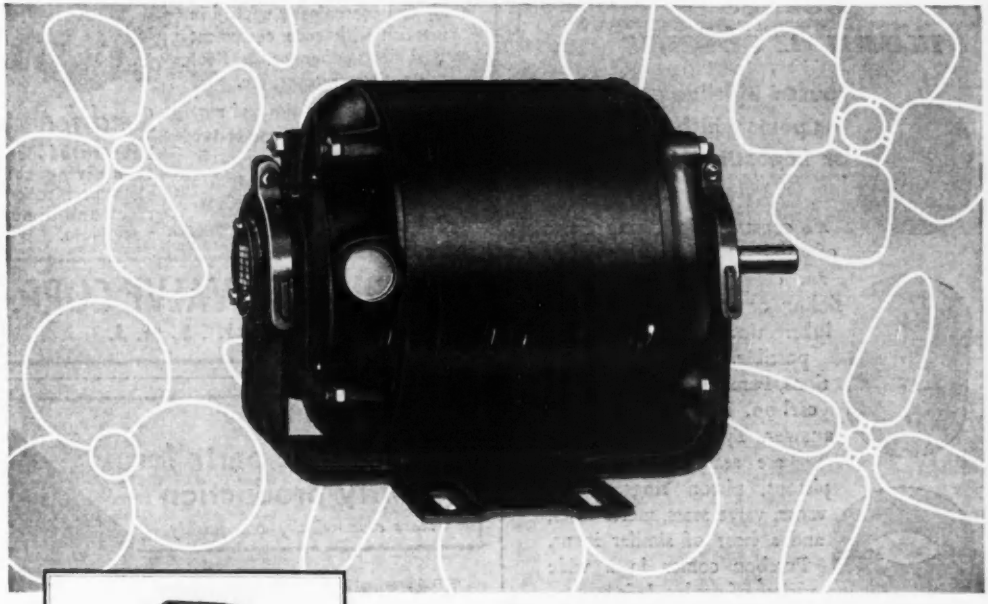

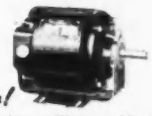

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Investigate the advantages of this new line of 1/6, 1/4 and 1/3 h.p. blower motors specifically designed for driving furnace blowers and similar types of air moving equipment.

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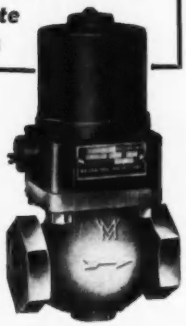

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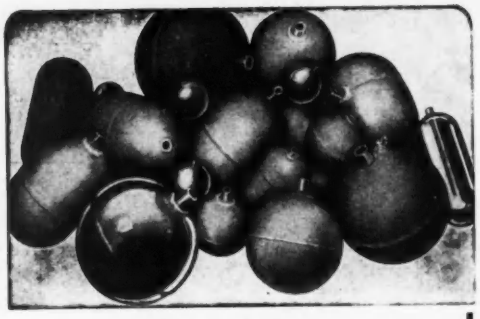

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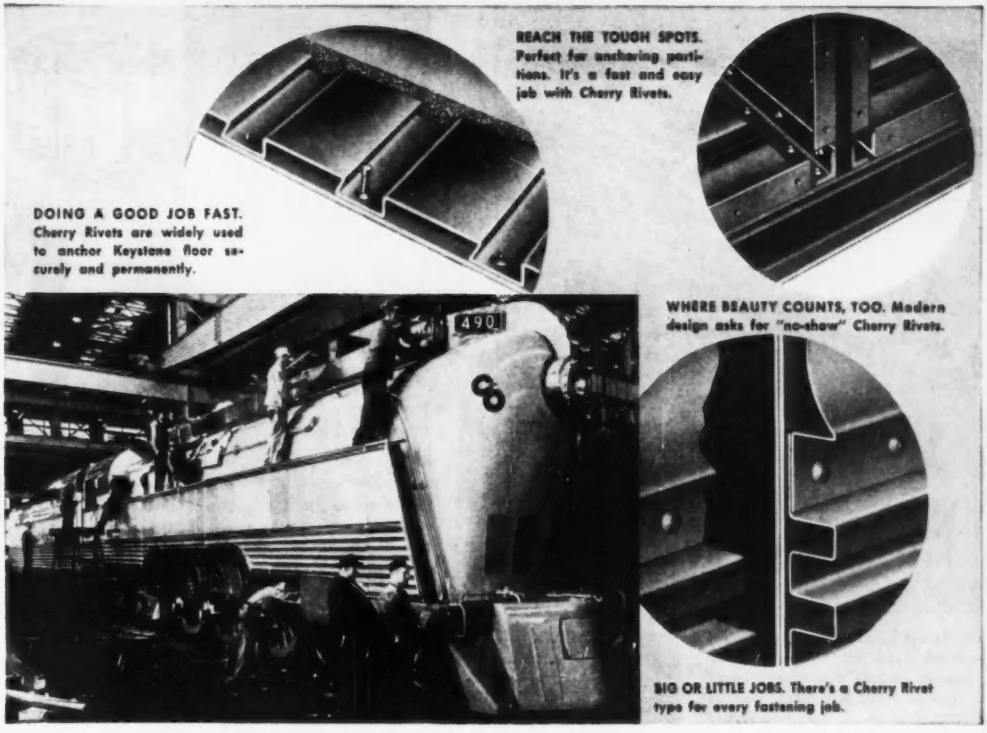
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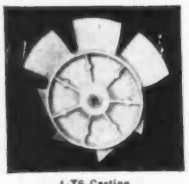

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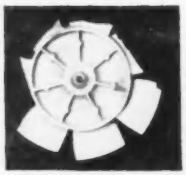

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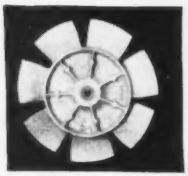

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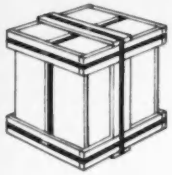

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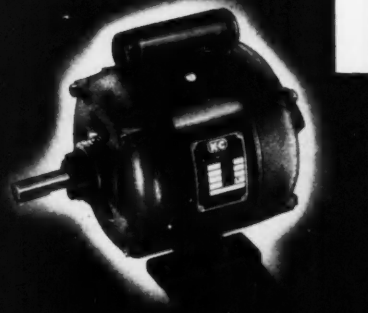

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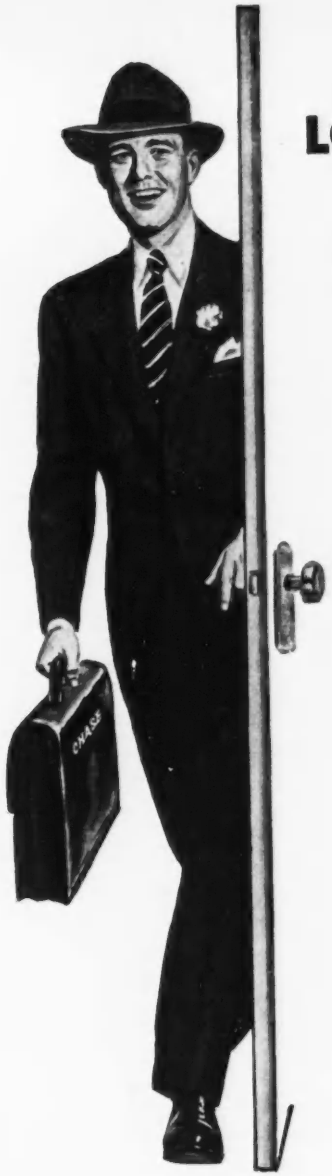

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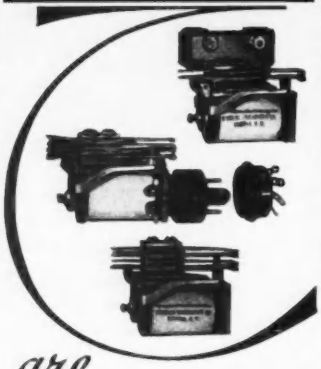

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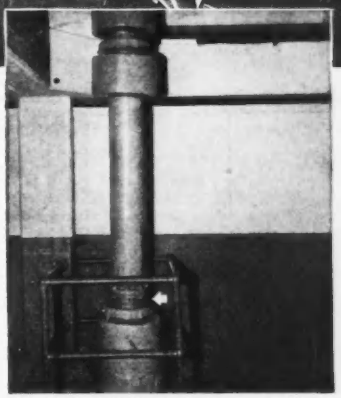

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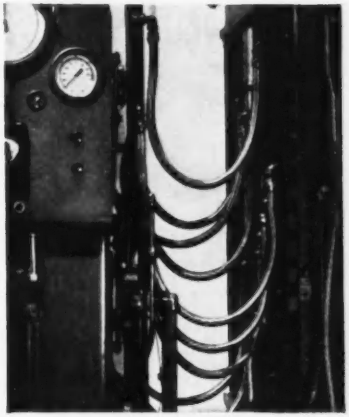

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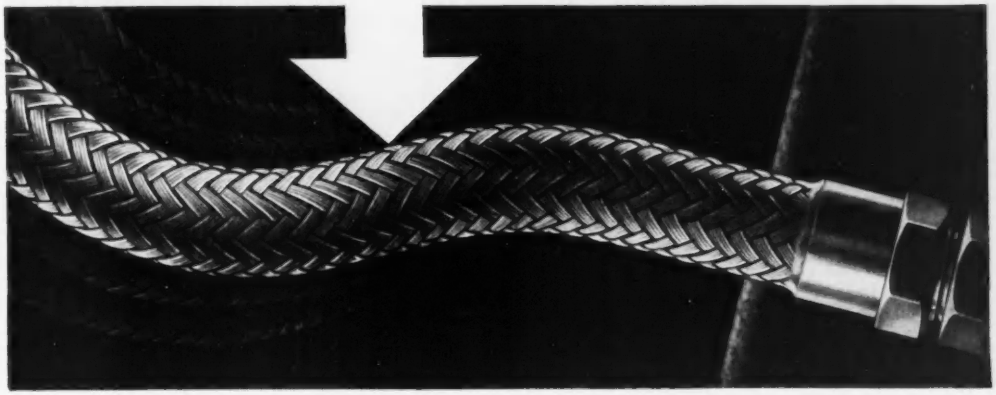

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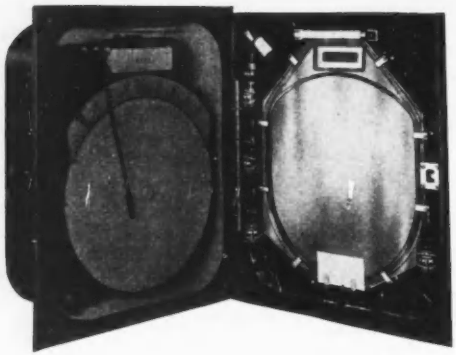
Molded from an impact type phenolic material, the 16" x 20½" door of this Hays-Penn Flow Meter was designed by Penn and Auburn. It weighs 3½ pounds. Internal bosses provide bases for mounting a fluorescent light, ink bottle holders, and the gasketed glass panel. A molded insert, reducing the size of the opening, adapts the door for use on the Penn Recorder-Controller, an entirely different instrument.



ADVANTAGES: Ribbed for strength, the door has good dimensional stability. Its flatness is important for precision instrument operation. Dust and moisture are excluded by all-around gasketing, plus a phenolic dust cover cemented to the top of the case flange. The properties of the phenolic material permit use under atmospheric conditions that would attack metals and finishes; the door serves as an insulating base for the electrical circuits it contains. No surface finishing is required; the smooth semi-matte surface is obtained in the molding process.

Successful solution of the problems involved in the proper design and production of this piece is typical of the "know-how" Auburn has developed in 73 years of experience. Whenever you have a problem in plastics, write Auburn Button Works, Inc., 350 McMaster St., Auburn, N. Y.

COMPRESSION, TRANSFER AND INJECTION MOLDING, AUTOMATIC ROTARY MOLDING FOR MASS PRODUCTION, EXTRUDED VINYL OR ACETATE TUBES AND SHAPES, MOLD ENGINEERING AND COMPLETE MOLD SHOP

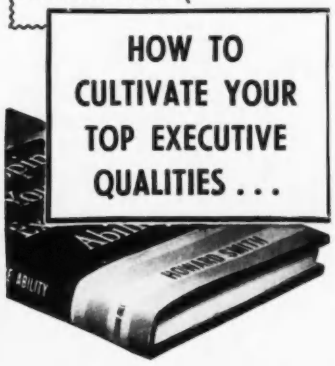
Engineered Plastics

MOLD MARK

Auburn Button Works, Inc.

MOLDERS SINCE 1876 • AUBURN, NEW YORK

What makes one man worth $40,000 — another only $4,000? . . . this book tells . . .



—and win success faster in the upper brackets

TOP EXECUTIVES aren't born. They're made. Self-made mostly. Though they rise along different routes, the steps to their success are similar. They follow a definite course of action . . . and arrive at the top **as planned.** Now, here is a practical, inspiring book which brings you this amazing success formula. It outlines a specific, detailed plan for cultivating the qualities which mark the top-flight business leader today—illuminating each point with intimate, on-the-job studies of currently outstanding executives.

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- 3 best methods for improving personality
- 11 ways to put over your personality
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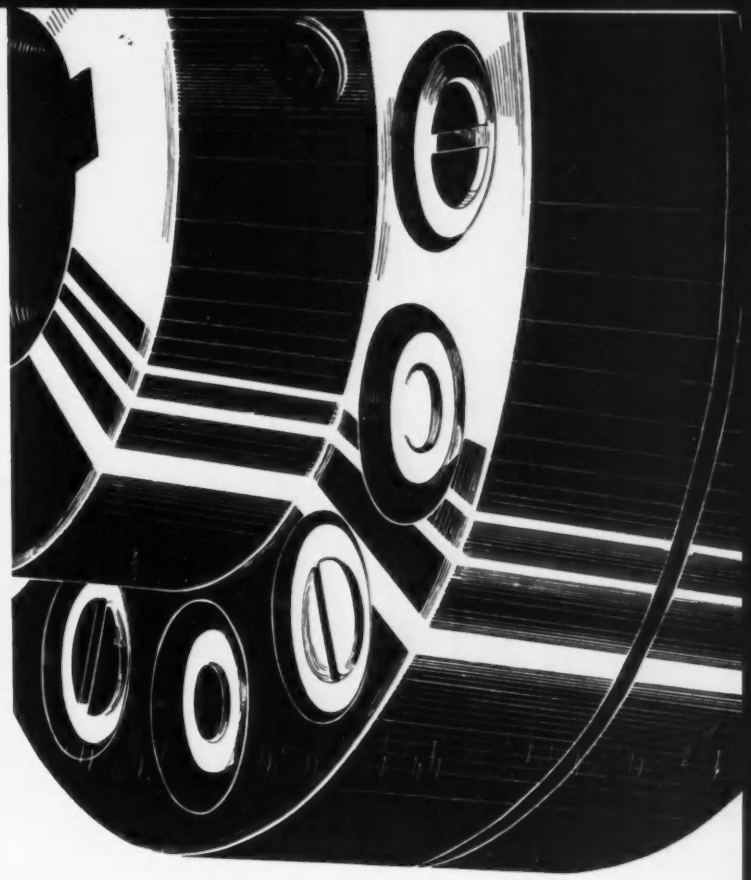

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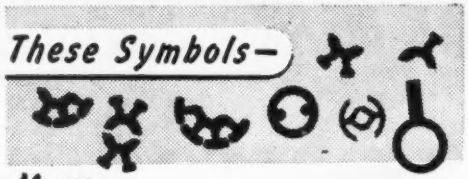

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They are the shapes of the standard contact elements used in ESCO multi-pole, rotary, detent switches. These elements, specially assembled to meet your particular switching requirements, permit a single control handle to operate a multi-pole, multi-stage, multi-position switch.

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cover wide operating needs

RATINGS	10A, 125 VAC — 5A, 250 VAC
POLES	One to 40
POSITIONS	4, 8, or 16
HANDLES	Oval, pistol-grip, removable
MOUNTINGS	Base or panel
CONNECTIONS	Side

COST . . . below that of most "standard" switches.

Write today for data sheets showing the structural details that provide ESCO'S unsurpassed versatility.

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For your heavy-duty applications, specify ESCO rotary snap switches . . . available in current ratings up to 200 amperes at voltages up to 460 a-c.

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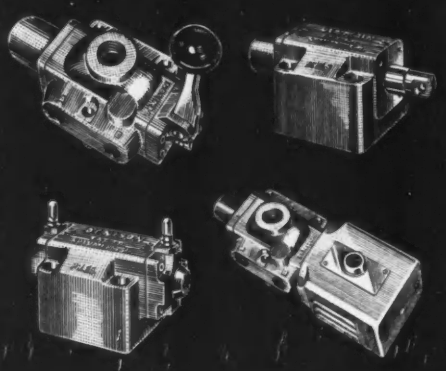
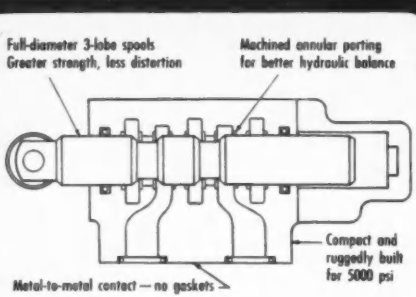
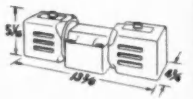




COMPACTNESS:
Check dimensions of the Denison ¾" double-solenoid valve shown at right, with those you are now using.



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Denison Valves with *any* valves on the market today. Compare them for space-saving size; lasting efficiency; modern, rugged construction; low cost. Send for bulletins VD-1 and VD-2 without delay!

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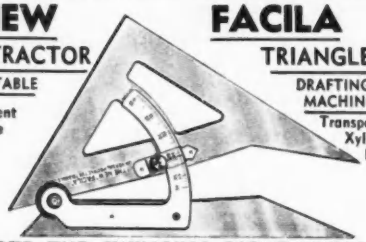

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Send for Descriptive Bulletin
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How to estimate the time any machining job will take

Whether a job involves drilling, boring, tapping, threading, grinding—or any other operation—this manual tells you exactly what to consider in estimating job-time. It covers every step—from setting up the job, to tearing it down—giving reasonable time values for each, based on actual experience.

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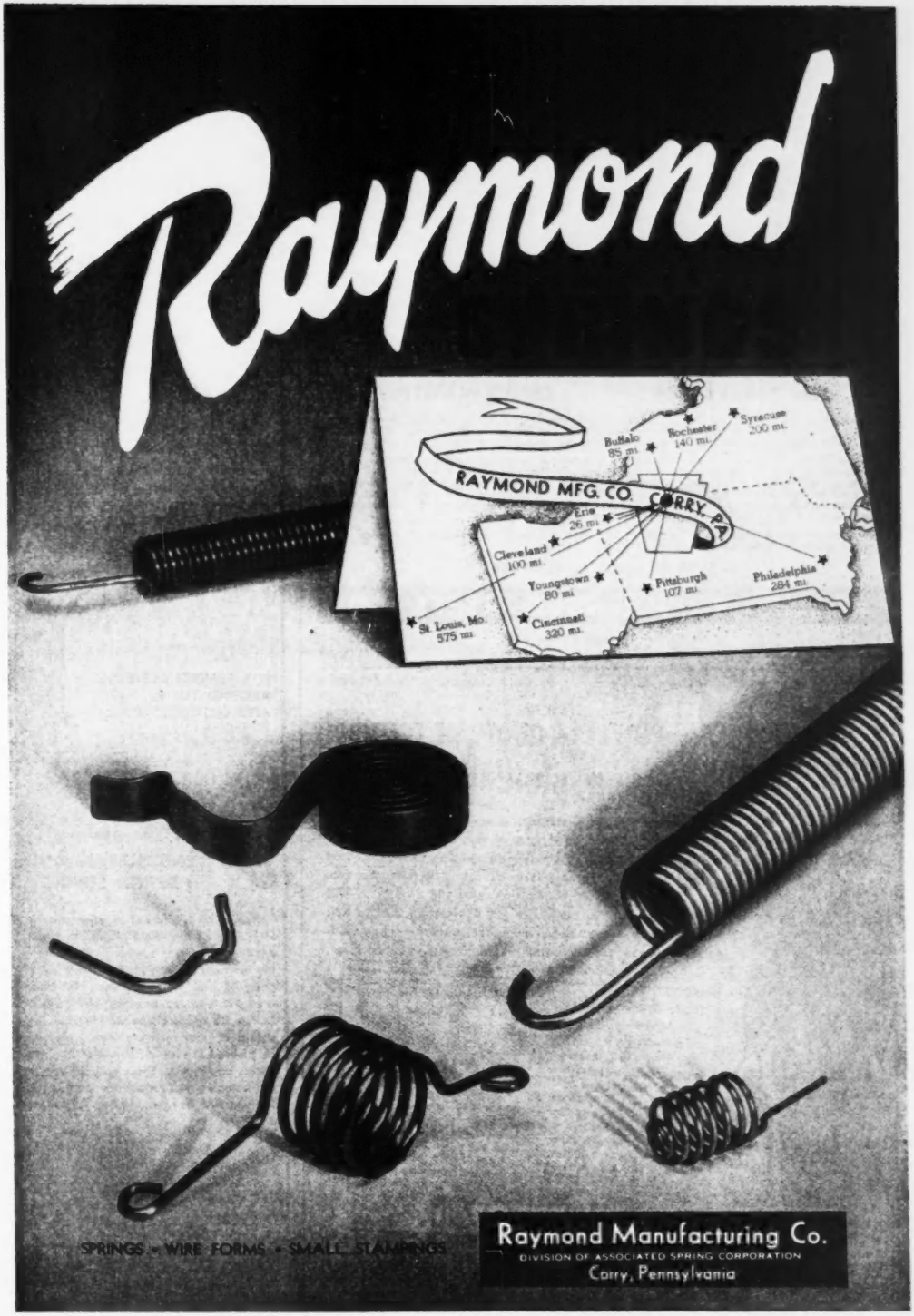
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284 mi.
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575 mi.
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320 mi.
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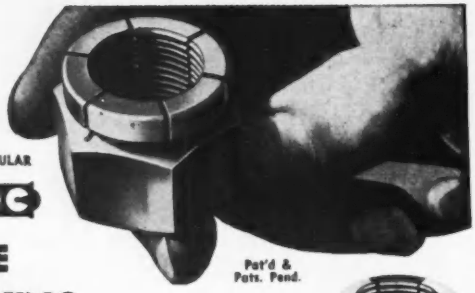
Raymond Manufacturing Co.
DIVISION OF ASSOCIATED SPRING CORPORATION
Corry, Pennsylvania



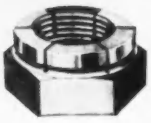
REGULAR

FLEXLOC

ONE-PIECE SELF-LOCKING NUTS

Pat'd & Pats. Pend.

THIN



. . . WON'T SHAKE LOOSE . . . REDUCE MAINTENANCE

Invariably, when nuts loosen, they cause shutdowns, loss of production, and bad tempers all around. All this can readily be eliminated by installing the one-piece, self-locking "FLEXLOC", because *it positively will not shake loose* and positively cuts cost of maintenance.

The all-metal, one-piece resilient "FLEXLOC" is becoming increasingly popular, because it is processed to have an exceptionally uniform torque and, because it packs a stop, lock and plain nut all in one. "FLEXLOC" accommodates itself to a wide range of thread tolerances and can be used over and over again without losing much of its torque. And, being a stop nut, it stays locked in any position on a threaded member. It is not affected by temperatures commonly met within the Industrial Field of Mechanical Engineering.

Available in "thin" and "regular" types—in sizes from #6 to 2" in diameter—in NC and NF thread series. Write for your copy of the "FLEXLOC" Catalog.

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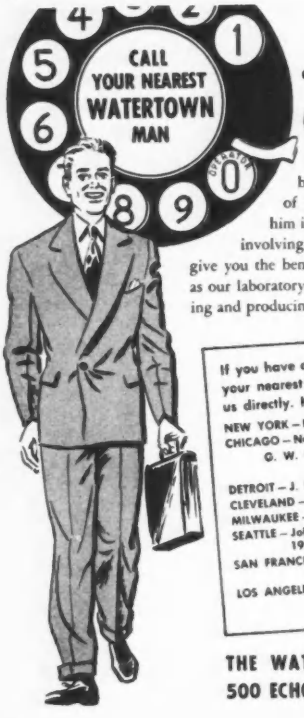

. . . to quote or counsel on molded plastics

Your Watertown man is an expert in plastics, backed by 34 years of experience with every type of plastic, every type of molding method. Calling him in to quote or consult on any part, product *or idea* involving molded plastic won't cost you a cent . . . will give you the benefit of our design and engineering skill, as well as our laboratory — second to none in the industry — in developing and producing the job to your satisfaction and your customers'.

If you have a custom molded plastics job on the fire, phone your nearest Watertown man today . . . or phone or write us directly. Here are the Watertown men . . .

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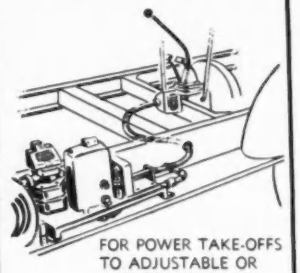
CHICAGO — National Insulations Company, 2808 W. Lake St.
G. W. Glaescher J. P. Greener R. C. Farquhar
J. P. Bonnamy J. R. Kallaher
DETROIT — J. P. Greener from Chicago
CLEVELAND — Carl F. Linn, 866 Hanna Bldg.
MILWAUKEE — Roger L. Miller, 729 N. Broadway
SEATTLE — John W. Witherow, National Vulcanized Fibre Co. 1927 First Ave., South
SAN FRANCISCO — G. W. Harmssen, National Vulcanized Fibre Co. 273 Seventh Ave.
LOS ANGELES — Fred M. Foley, National Vulcanized Fibre Co. 2325 East Eighth St.

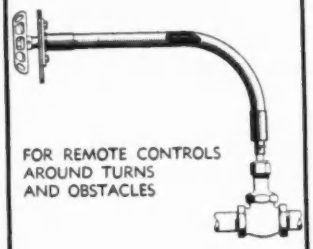
THE WATERTOWN MANUFACTURING CO.
500 ECHO LAKE RD., WATERTOWN, CONN.

Elliott

FLEXIBLE SHAFTING



FOR POWER TAKE-OFFS TO ADJUSTABLE OR OUT-OF-LINE PARTS



FOR REMOTE CONTROLS AROUND TURNS AND OBSTACLES

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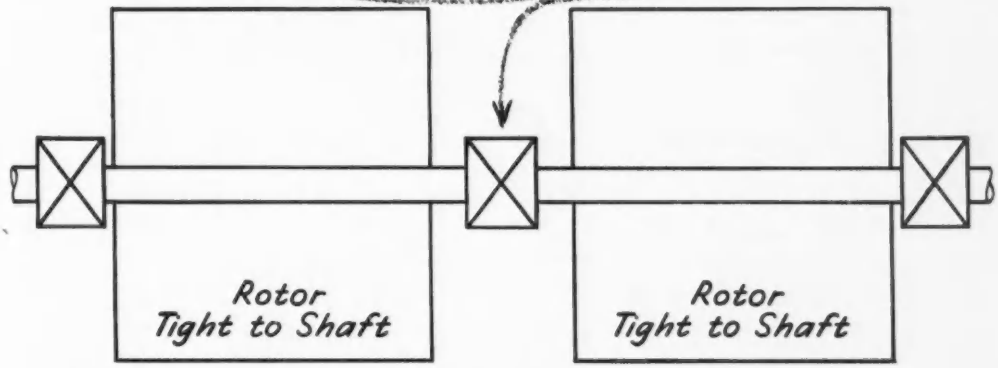
Backed by 50 years of experience in the Flexible Shaft and related fields, the Elliott engineering staff is constantly incorporating new and modern improvements in the design of their own equipment. This staff is available to you, as a part of the Elliott Service, to cooperate in working out the details of your own problems. We will be pleased to supply Flexible Shaft Data Sheets on request. These will aid you in furnishing us with certain necessary specifications such as r.p.m., torque, deflection, etc.

Write for Catalog 49 on your Company Letterhead

ELLIOTT
MANUFACTURING COMPANY
216 PROSPECT AVE. BINGHAMTON, N. Y.

Split Pillow Block



THERE IS NO PROBLEM in installing a conventional center support bearing when this unit is assembled at the factory.

BUT WHEN THAT BEARING FAILS in service, replacement is quite another story! The cost of maintenance men and down time on production may run to *50 times the cost of the bearing itself.*

A Split Pillow Block in that center position or any similar design can be replaced in a matter of minutes. The potential buyer of equipment is interested in the "better" design afforded by the use of this unit.

OUTER RACE INNER RACE

In sizes from 15/16" to 3-15/16" dia. shafts with "split" or divisible inner and outer race. Write for print with complete data to Dept. P9-49.

THESE EIGHT POINTS ARE WORTH READING

1. Both the inner race and outer are "split". This permits installation in places where the solid race bearing cannot be installed.	2. The outer race is also the pillow block, made from a forging of bearing steel, into which the ball race is ground to close tolerances.	3. Center height is held to a close tolerance and can be increased by means of adapter plates. Screw holes in base of the outer race of housing secure the unit to its related part.	4. The seal rides into a free fitting groove in the inner race and is retained by a groove in the outer race — a highly effective labyrinth type of seal.
5. There is a large space for lubricant with a grease fitting for lubrication.	6. Because of the split feature, a greater number of balls can be assembled in the bearing than is possible with solid race construction.	7. They are designed as either rigid or self-aligning type with a synthetic retainer. The ball pockets are drilled. No rivets — no crimping.	8. The inner race is positioned by drawing up on four screws which locks the inner race to the shaft.

·DIVISIBLE RACE BEARINGS·

SPLIT BALLBEARING CORPORATION

LEBANON, NEW HAMPSHIRE, U.S.A.

DO THINGS

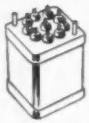
YOU NEVER DID BEFORE... with G-E SILICONE RUBBER

Manufacturers find this remarkable silicone-formulated rubber permits many applications impractical with ordinary rubber. The chemical inertness, temperature resistance, and electrical properties of G-E silicone rubber may mean either the solution to a troublesome production problem or a chance for new sales—for this rubber may enable you to make items you never could before.

ACTUAL APPLICATIONS OF G-E SILICONE RUBBER

GASKETS. The Kinney Manufacturing Company utilizes resilient, chemical-resistant G-E silicone rubber for gaskets with more positive shut-off action in its vacuum-tight valves for use, in mercury steam power plants.

SEALING DISCS. The Watts Regulator Company found only one material reliable enough for the disc in this vacuum relief valve which guards homes against hot water tank collapse—stable, flexible, G-E silicone rubber.



BUSHINGS. The Raytheon Manufacturing Company uses self-sealing G-E silicone rubber bushings on a special type of transformer for naval radar.

Can G-E silicone rubber help *your* production or create new business for *you?* Write to Section 6-9, Chemical Department, General Electric Company, Pittsfield, Massachusetts.

GE SILICONE RUBBER

CD49-G4

GENERAL ELECTRIC

GENERAL CONTROLS . . .
THE ACKNOWLEDGED STANDARD IN AUTOMATIC PRESSURE, TEMPERATURE, LEVEL AND FLOW CONTROL UNITS
Here are a few of an outstanding line of Controls for Industrial, Commercial and Domestic applications.
•ALL GAS CONTROLS
•AIRCRAFT CONTROLS ELECTRIC
•AUTOMATIC SAFETY PILOTS
•GAS REGULATORS
•LOW WATER CONTROLS
•GOVERNOR TYPE VALVES
•HI-LOW OFF VALVES
•INDUSTRIAL VALVES
•LOW PRESSURE GAS VALVES
•MOTOR OPERATED VALVES
•MAGNETIC GAS VALVES
•PILOT BURNERS
•PILOT GENERATORS
•REFRIGERATION VALVES
•SOLENOID VALVES
•STRAINERS—RELAYS
•GAS COCK SAFETY VALVES
•THERMOSTATIC CONTROLS
•TRANSFORMERS—SWITCHES
•THERMOPILOTS
Controls for air, water, steam, natural, manufactured and liquefied petroleum gases, light and heavy oils, etc., refrigerants such as freon, methyl chloride, sulphur dioxide and ammonia.
A.C. or D.C., normally closed or open types. High and low pressures and temperatures. PROVED AND IMPROVED PERFORMANCE IS PROOF THAT YOU CAN'T BUY BETTER CONTROLS
FOR COMPLETE SPECIFICATIONS REQUEST NEW CATALOG
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FACTORY BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

LaPLANT-CHOATE HYDRAULIC UNITS *AVAILABLE NOW* FOR YOUR HEAVY DUTY EQUIPMENT

SEND FOR THIS 16 PAGE BULLETIN TODAY!

It's chuck-full of Construction Details, Performance Data, Dimension Drawings, Installation Data.

Here's valuable information on the complete line of LaPlant-Choate Hydraulic Products . . . hydraulic pumps, motors, valves, cylinders and compact 3-in-1 control units. The LaPlant-Choate Hydraulic line—result of 24 years' experience in building hydraulic controls for our own earthmoving and land-clearing equipment—is now available to provide safe, efficient and economical hydraulic power for your heavy duty equipment. Get the complete story—send for your copy of BulletinA-1152E.

LaPLANT-CHOATE MFG. CO., INC.
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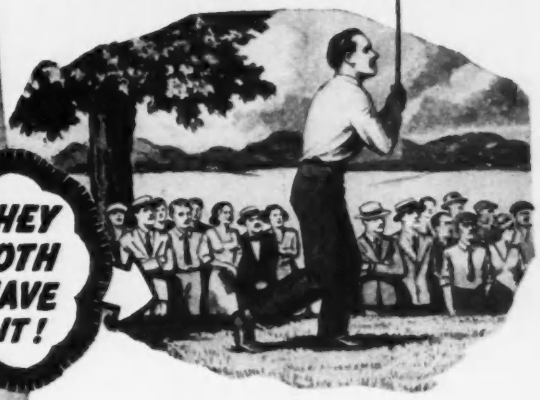
The "EXTRA SOMETHING" that spells TOP PERFORMANCE



THEY BOTH HAVE IT!

Championship honors in golf are not achieved by chance. The contender who grabs the title must have a more powerful drive, a keener sense of distance and steadier nerves—a combination that gives him the "extra something" required for championship performance.

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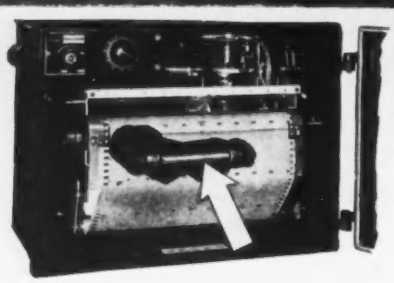

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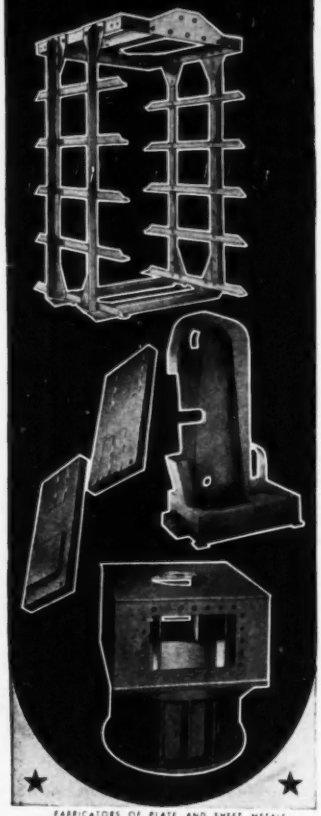

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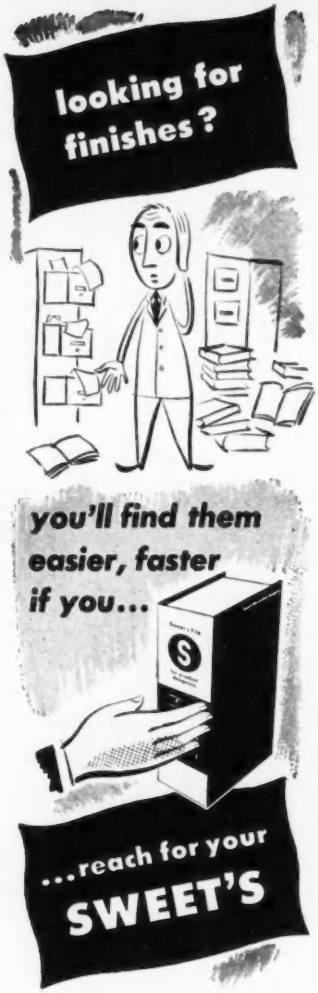

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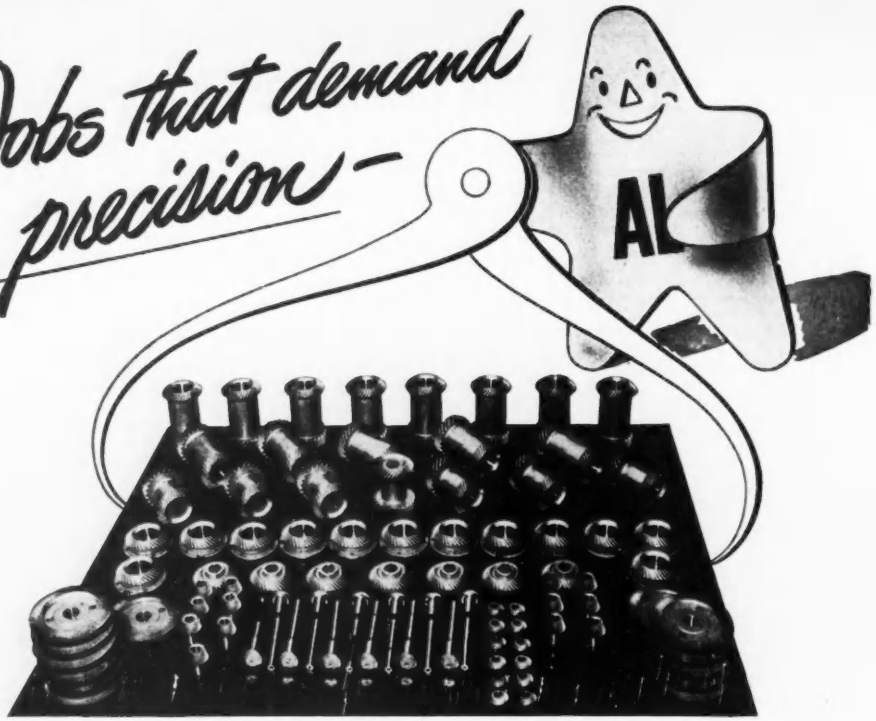

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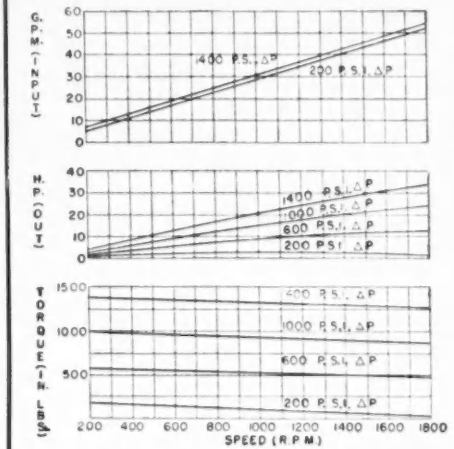

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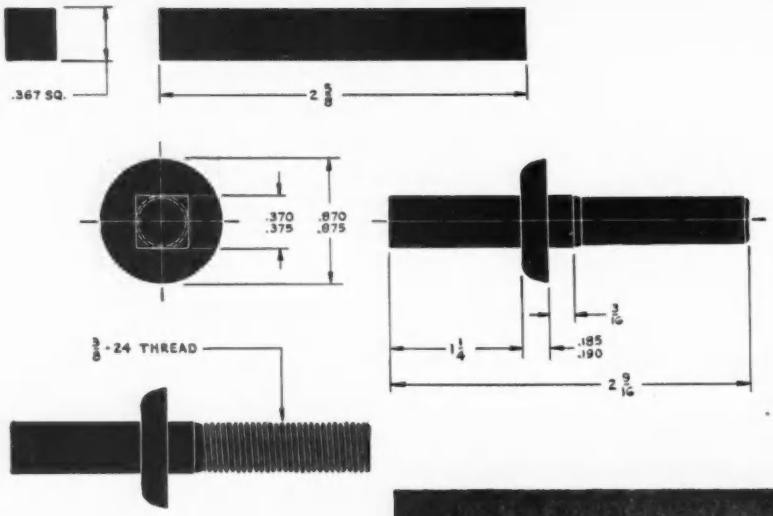

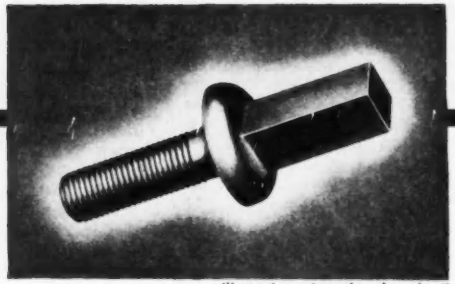

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NOW READY, "Guide to the Profitable Use of Cold Heading" —Bulletin No. 2. Here are more examples of the advantages and limitations in designing parts for cold heading. *Send now for your copy.*

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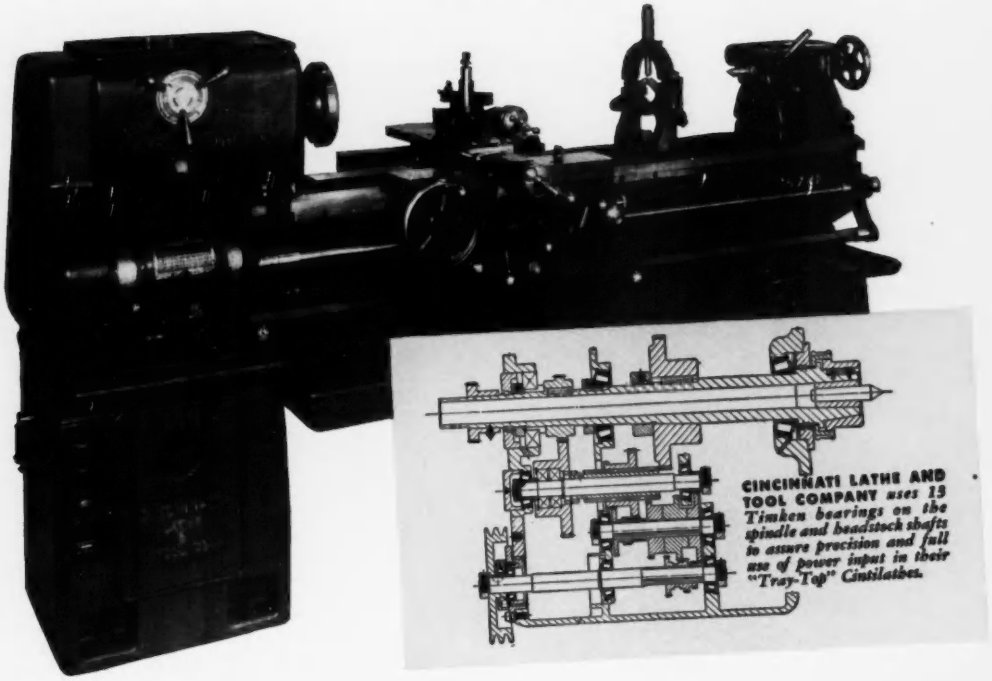
This symbol on a product means its bearings are the best.



CINCINNATI LATHE AND TOOL COMPANY *uses 13 Timken bearings on the spindle and headstock shafts to assure precision and full use of power input in their "Tray-Top" Cintilathes.*

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